Identifying Habitat Rehabilitation Targets and Priorities in Great Lakes Areas of Concern: Upland Systems

An Interim Report For Circulation and Comment

January 1996

Remedial Action Plan
Plan d'Assainissement

Canada Ontario
Canada-Ontario Agreement Respecting Great Lakes Water Quality
L'Accord Canada-Ontario relatif à la qualité de l'eau dans les Grand Lacs

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Prepared by:
Environment Canada
Ontario Ministry of Natural Resources
Ontario Ministry of Environment and Energy

TABLE OF CONTENTS

FIGURES

APPENDICES

EXECUTIVE SUMMARY

There is a growing body of literature on the necessity of protecting a well-vegetated, linked system of habitats across a watershed (i.e. Humber River watershed in Metro Toronto), or larger land unit like a bioregion (the Greater Toronto Area), or physiographic unit (i.e. Oak Ridges Moraine). These exercises have shown that current habitats are fragmented and in poor condition due to a variety of factors including past land use planning decisions, and therefore must be rehabilitated to function as healthy fish and wildlife habitats.

Since 1988, Remedial Action Plan (RAP) teams in Areas of Concern (AOC) across the Great Lakes basin have been developing clean up actions that include strategies to restore fish and wildlife habitat across these impoverished landscapes. In developing habitat rehabilitation strategies, RAP Teams and Public Advisory Committees (PACs) must grapple with questions encompassing both ecological and financial realities: Within the limits of available time and funds, which rehabilitation projects should receive priority? When has the habitat been re-assembled to the point when it can be considered restored?

To assist RAP participants in answering these difficult questions, habitat targets have been developed for upland systems in an AOC watershed. These targets have been developed to help RAP Teams and PACs measure the degree of upland habitat rehabilitation that may be needed before the loss of fish and wildlife beneficial use impairment (BUI) can be considered restored. Should these targets be difficult to attain in a particular AOC watershed, threshold levels have been provided that show how the biological community is affected by meeting only part of a target (see figures 2.1 and 2.2). A complementary document, currently under preparation will discuss aquatic habitat targets in the same manner. A procedure using geographic information system mapping is recommended whereby the current state of habitats is identified and measured against the targets. Once the status of habitat loss and fragmentation is known, priority rehabilitation projects are designed and implemented. Progress towards delisting the AOC is measured against the targets and thresholds.

The upland habitat targets are most relevant to areas of southern and northern Ontario that are dominated by agricultural and urban landscapes. In less-effected areas such as Nipigon Bay, habitat rehabilitation strategies will likely focus on site-specific water quality and aquatic habitat needs as the majority of the watershed remains well-forested.

De plus en plus de documents expliquent la nécessité de protéger un système lié et bien couvert de végétaux d'habitats répartis dans un bassin hydrologique (bassin hydrologique de Humber River du Grand Toronto), une zone plus grande (la zone du Grand Toronto) ou une entité physiographique (moraine de Oak Ridges). Ces exercices ont établi que les habitats actuels sont fragmentés et en mauvais état du fait de divers facteurs, dont d'anciennes décisions prises pour affecter les terrains, et qu'il faut donc restaurer ces habitats, en les rendant salubres pour les poissons et d'autres animaux.

Depuis 1988, les équipes du Plan d'assainissement (PA) des secteurs préoccupants (SP) du bassin des Grands Lacs conçoivent des plans d'assainissement qui comprennent des stratégies visant à restaurer l'habitat des poissons et d'autres animaux dans les sites épuisés. Pour élaborer les stratégies de restauration, les équipes du PA et les Comités consultatifs publics (CCP) doivent s'attaquer à des questions qui englobent des réalités tant écologiques que financières : Dans les limites du temps et des fonds disponibles, à quels projets de restauration doit-on donner la priorité? Jusqu'à quel point doit-on remettre l'habitat en état avant de pouvoir le considérer comme restauré?

Pour aider les participants du PA à répondre à ces questions difficiles, on a fixé des objectifs d'habibat pour les systèmes des terres non immergées du bassin hydrologique d'un SP. Ces objectifs aident les équipes du PA et les CCP à mesurer le degré de restauration de l'habitat des terres non immergées qu'il faudrait atteindre afin de pouvoir considérer comme compensée la perte due à la détérioration des utilisations bénéfiques (DUB) des zones à poissons et autres animaux. S'il est difficile de réaliser ces objectifs pour un bassin hydrologique d'un SP, on a fixé des seuils qui montrent comment le milieu biologique est touché si l'on n'atteint qu'une partie des objectifs (figures 2.1 et 2.2). Un document complémentaire, en cours de préparation, discutera de la même façon des objectifs d'habitat aquatique. On conseille une méthode qui utilise l'établissement de cartes du système d'information géographique, qui permet d'établir l'état actuel des habitats et de le mesurer par rapport aux objectifs. Une fois connu l'état de perte et de fragmentation de l'habitat, on conçoit et applique des projets prioritaires de restauration. Pour enlever un SP de la liste, on se fonde sur les objectifs et les seuils.

Les objectifs d'habitat des terres non immergées sont plus pertinents dans les zones du sud et du nord de l'Ontario dominées par les terrains agricoles et urbains. Dans les zones moins touchées de la baie Nipigon, les stratégies de restauration de l'habitat se concentreront sans doute sur les besoins des habitats aquatiques et les besoins en qualité d'eau qui touchent à des sites particuliers, car la plupart des bassins hydrologiques restent bien boisés.

1. INTRODUCTION

1.1 Background and Purpose

The Great Lakes Remedial Action Plan (RAP) program originated from a recommendation in 1985 from the International Joint Commission's Great Lakes Water Quality Board. The purpose of RAPs is to restore degraded areas in the Great Lakes.

There are six fish and wildlife related beneficial use impairments (BUI) listed in the 1987 Great Lakes Water Quality Agreement:

- loss of fish and wildlife habitat
- degradation of fish and wildlife populations
- fish tumours or other deformities
- bird or animal deformities or reproductive problems
- tainting of fish and wildlife flavour
- restrictions on fish and wildlife consumption

In 1994, the rehabilitation of degraded areas became one of three primary objectives of the Canada-Ontario Agreement (COA) Respecting the Great Lakes Basin Ecosystem. The COA commits Canada and Ontario to the rehabilitation of 60% of impaired beneficial uses across all 17 Areas of Concern (AOCs) leading to the delisting of nine AOCs by the year 2000 (one AOC, Collingwood Harbour, has already been delisted). In addition, COA provides targets for the rehabilitation of 6,000 hectares of wetland habitat and 600 kilometres of riparian habitat by 2000.

The purpose of this document, Identifying Habitat Rehabilitation Targets and Priorities in Great Lakes Areas of Concern: Upland Systems (hereafter referred to as the Upland Systems document) is to help RAP Teams and Public Advisory Committees (PACs) identify upland habitat rehabilitation needs and priorities. By providing a methodology using targets and geographical information system technologies, the document demonstrates a way in which to measure success towards restoring two BUIs: firstly, loss of fish and wildlife habitat and secondly, through providing renewed habitat, degraded fish and wildlife populations. In turn, by identifying habitat rehabilitation needs, RAP teams can assist in meeting the COA targets listed above. For example, by mapping first to third order streams, priorities can be set for locations requiring revegetation, and geographic information systems can be used to measure progress towards the COA target of 600 kilometres of rehabilitated riparian habitat.

1.2 A Methodology for Comprehensively Identifying Habitat Rehabilitation Priorities in Upland Systems: using the Natural Heritage System Approach

The concept of a natural heritage system has rapidly been endorsed by many agencies and interest groups in Ontario. Recent documents detailing a natural heritage approach include *Natural Heritage System for the Oak Ridges Moraine Area: GTA Portion* (Geomatics International 1993) and *The Natural Heritage of Southern Ontario Settled Landscapes* (Riley and Mohr 1994). Many of the underlying principles and methodologies associated with a natural heritage approach are consistent

with achieving the goals of habitat rehabilitation within the AOCs. Many municipalities are using this approach to map significant wetlands, woodlands and fish and wildlife habitats for protection in their official plan documents.

The overall philosophy of a natural heritage approach is succinctly described by Riley and Mohr (1994):

> **"Natural heritage systems" are identified as a method for defining integrated networks of conservation lands and waters, linked by natural and restored corridors. They are a practical technique to define conservation and protection objectives in land-use, watershed and resource planning. They can also define base-line or benchmark landscape systems against which to monitor cumulative environmental effects and assess acceptable levels of landscape change.**

Steps to a natural heritage strategy are described by Riley and Mohr (1994). The challenge to the RAPs is to apply this concept to AOCs where the focus is not only protection of these habitats, but rehabilitation.

1.3 RAPs and Land-use Planning in Municipalities: Linking the Complementary Objectives of Habitat Rehabilitation and Protection

In 1994, the province introduced the Comprehensive Set of Policy Statements under Section 3 of the Planning Act. A primary objective of the province's new Comprehensive Set of Policy Statements focused on "Protecting the Environment". With the creation of a new policy entitled "Natural Heritage Environmental Protection and Hazard Policies", the province took a significant step. This new policy (currently under review) may require municipal governments to make decisions on new applications that "shall be consistent with" the goals of the new policies. Pending the outcome of the current review of planning reform, elements of natural heritage protection may be embraced in these policies and associated implementation guidelines.

Currently the implementation guidelines define specific habitats and adjacent lands for protection and rehabilitation including:

- Significant ravine, river and stream corridors
- Significant portions of the habitat of endangered, threatened and vulnerable species
- Significant woodlands
- Shorelines of lakes, rivers and streams
- Significant natural corridors

Wetlands, fish habitat, groundwater recharge areas, headwaters and aquifers are also part of the natural heritage system but are addressed under other policy statements (under review).

The type of approach described by Riley and Mohr (1994) has been applied to the Oak Ridges Moraine (Geomatics International, 1993) and the Couchiching-Severn Region (Reid and Patterson, 1994). There are also similar on-going initiatives in municipalities that are associated with RAPs:

Simcoe County and Tay Township for Severn Sound, the Region of Hamilton-Wentworth for Hamilton Harbour, and the Metro Toronto and Region Conservation Authority's Humber River strategy in Metro Toronto.

Municipalities recognize that achieving the type of intact natural heritage systems suggested under new planning legislation will not be possible by only protecting habitats in the condition that they remain today. Instead, they realize that due to the degraded nature of these areas, rehabilitation will be required. RAP teams can provide the rehabilitation focus that will lead to renewed natural heritage systems that are no longer fragmented and ecologically unsustainable; systems that include restored fish and wildlife habitat and populations.

Many of the underlying principles and methodologies associated with a natural heritage approach are consistent with achieving the goals of habitat rehabilitation within the AOCs. By working with municipalities and conservation authorities, long-term implementation of RAP habitat protection and rehabilitation goals and targets can be assured.

The following chapters provide rationale for the choice of upland habitat rehabilitation targets, describe the data and mapping required, outline a step by step methodology for determining upland habitat rehabilitation needs in an AOC watershed, and report on two examples used to test the approach: Nipigon Bay and two different sub-watersheds in the Humber River watershed in Metro Toronto.

2. DEVELOPING UPLAND HABITAT TARGETS IN AOCs

Loss of biodiversity is recognized as one of today's most severe environmental problems, and habitat fragmentation and degradation is considered to be the main cause (Rosenburg and Raphael, 1986). The argument that the environment ought to be managed from an ecosystem or landscape perspective is gaining support and urgency (Rowe, 1992; Thompson and Welsh, 1993; Slocombe, 1993). Concerted effort must be made regionally to maintain ecosystem composition and landscape structure not only in parks and protected areas but throughout larger areas (i.e. entire watersheds).

The study of landscape ecology deals with the spatial patterns of landscapes (Forman and Godron, 1986). Attention to measures of habitat size, shape, and distribution all contribute significantly to the understanding of landscape structure. Numerous studies have been conducted which illustrate these types of measures and their use in landscape quantification (Reinhardt, 1990; Turner, 1990; LaGro, 1991). Due to the spatial nature of these calculations, Geographic Information Systems (GIS) technology can be extremely useful (Haines-Young et al., 1993).

2.1 HABITAT TARGETS DERIVED FROM LANDSCAPE ECOLOGY CONCEPTS

2.1.1 Upland Habitat Rehabilitation Targets

Rehabilitation of upland habitat within the natural landscape context requires establishing targets for the AOC. By establishing overall targets individual projects can be evaluated with respect to their contribution toward restoring the loss of fish and wildlife beneficial use impairment.

The targets suggested below apply to all 16 AOCs in Ontario. They serve as guidance, and the definition of site specific AOC targets is encouraged. It should be noted that the goals for upland habitat restoration are most relevant to southern Ontario landscapes that are dominated by agricultural and urban landscapes. In more heavily-forested regions of the province, the strategy should focus on water quality and aquatic habitat while ensuring that existing terrestrial habitat is not degraded. A rationale for the choice of targets follows.

2.1.2 Habitat Targets and Thresholds

Upland targets developed for this strategy focus on riparian and forest ecosystems. Fish and wildlife habitat in the AOCs should be restored above threshold levels, where practical, to support self-sustaining populations of representative plant and animal species. Table 2.1 summarizes the habitat targets for upland habitat in AOCs.

Table 2.1. Habitat Targets

Parameter	Target	Rationale
Percent Forest Cover in Watershed	> 30	will support most bird species expected within range
Size of Largest Forest Patch (minimum of 500 m wide)	100 ha	will support most bird species expected within range
Percent of Watershed that is Forest Cover 100 m or farther from edge	> 10	will support most forest-interior and edge bird species
Percent of Watershed that is Forest Cover 200 m or farther from edge	> 5	will support most forest-interior bird species expected within range
Percent of Riparian Habitat that is Vegetated along First to Third Order Streams	> 75	should maintain high stream integrity assuming no other major problems; may maintain coldwater
Percent of First to Third Order Streams with at least 30 m wide buffers	> 75	should maintain high water quality and stream integrity
Percent of Watershed that is Impervious	< 15	potential to maintain coldwater streams

The ultimate target is to attain a natural heritage system that exhibits a high degree of biodiversity, while improving water quality in streams. There may be instances where existing conditions preclude target achievement. It is then necessary to know what the benefits of a less-extensive strategy will be, and when an AOC may be delisted even though it does not meet the targets. Thresholds that represent levels towards target achievement are presented in Table 2.2

It should be noted that the suitability of habitat for birds and other species is affected by factors working in association. In addition, a number of other factors that are not suitable for developing targets like habitat shape and proximity of forests to each other influence the number of bird species able to use an area. For a discussion of these factors see the reference to bird species abundance in the Region of Haldimand-Norfolk desribed on page 11, and in section 2.3. Related Ecological Factors ... on page 16-17.

Table 2.2. Thresholds

Parameter	Thresh-old	Level of Achievement
Percent Forest Cover in Watershed	20-30	should provide habitat for about 90% of bird species
	15-20	should provide habitat for about 80% of bird species
	10-15	should provide habitat for about 60 to 70% of bird species
	< 10	should provide habitat for 50 to 60% of bird species but only about 20% of forest-interior bird species
Size of Largest Forest Patch (minimum of 500 m wide)	75 ha	will support most bird species except a few with very large home ranges
Note: patches smaller than 25 ha cannot achieve a minimum width of 500 m	50 ha	will support some forest-interior and area-sensitive bird species, but several will be missing and edge species will dominate
	30 ha	may support a very few forest-interior and area-sensitive bird species
	20 ha	no forest-interior bird species but possibly some area-sensitive species
	< 20 ha	will support forest-interior and edge bird species
Percent of Watershed that is Forest Cover 100 m or farther from edge of woodland	5-10	will support 80 to 90% of forest-interior and edge bird species
	2-5	will support 60 to 80% of forest-interior and edge bird species, but they will be restricted in distribution
	< 2	will support a maximum of 50% of forest-interior and edge bird species, usually restricted to 1 or 2 locations
Percent of Watershed that is Forest Cover 200 m or farther from edge	3-5	will support about 70 to 80% of forest-interior bird species in scattered locations
	1-3	will support about 40 to 70% of forest-interior bird species in isolated locations
	< 1	very few forest-interior bird species; restricted to 1 or 2 locations if present

Table 2.2. Thresholds

Parameter	Thresh-old	Level of Achievement
Percent of Riparian Habitat that is Vegetated along First to Third Order Streams	50-75	may maintain a functional warmwater stream
	25-50	some nutrient enrichment, algae problems and shoreline erosion probable
	< 25	stream will be degraded; severely limited fisheries
Percent of First to Third Order Streams with at least 30 m wide Buffers	50-75	may maintain a functional warmwater stream and relatively good wildlife corridors
	25-50	some nutrient enrichment is likely and wildlife movement will be impeded among some areas
	< 25	stream may be degraded and wildlife movement may be inhibited
Percent of Watershed that is Impervious	10-15	potential to maintain high quality warmwater stream
	15-20	potential to maintain moderate quality warmwater stream
	< 20	stream likely to lose its integrity and become degraded

2.2 SUPPORTING EVIDENCE FOR CHOICE OF UPLAND HABITAT TARGETS

Birds are used as indicators of the quality of the landscape because they are easily surveyed and more is known about their habitat requirements and distribution than any other group of wildlife. Most of the large mammal species (otter, mink, martin, bobcat, wolf and bear) are sensitive to fragmentation as evidenced by their extirpation from most of southern Ontario. In contrast, much less is known about invertebrates, amphibians, reptiles, plants, and small mammals.

One of the key factors that contributes to the loss of birds from a fragmented landscape is the concept of metapopulations (semi-isolated populations in a region, linked by dispersion). Local extirpations of populations occur naturally within forests due to failed reproductive efforts because of factors such as predation, parasitism, adverse weather conditions, and insufficient food. Under normal circumstances, woodlots become recolonized by individuals from adjacent areas. However, as natural areas decline, there may be no source of colonists and extirpations may become permanent. Recent

studies suggest that the same factors may regulate amphibian populations.

The metapopulation concept (Villard *et al.*, 1992) can be used to explain the fact that the breeding bird assemblage in forests changes annually. Common species are always present, but the more specialized species are sporadic in occurrence. It has been demonstrated that the number of breeding pairs in a region remains almost constant, but that the areas used for breeding vary. Thus, a woodland may support a given species as infrequently as once every four or five years, yet this woodland is still critical to the overall maintenance of the regional populations. As even apparently insignificant woodlands disappear from the landscape, the size of wildlife populations declines.

The factors outlined below do not act in isolation to influence how habitats are used by fish and wildlife: forest size, shape, and degree of landscape fragmentation all come into play when various species choose their required habitats. Therefore these factors should be viewed collectively when applying this strategy to determine habitat rehabilitation needs and priorities.

2.2.1 Percent Forest Cover

The amount of forest cover in a landscape determines its ability to support wildlife species. This is particularly true for mammals that require extensive forests. Species such as gray wolf, lynx, wapiti, black bear and wolverine disappeared from southern Ontario shortly after forest clearing was initiated.

As the amount of forest habitat in an area declines, so do the number of breeding bird species. Forest-dependent birds are affected the most. In the Ottawa area, several species of forest birds disappeared as breeders when forest cover declined below 30% in a particular study area (Freemark, 1988). In Essex County, which contains only about 3% natural habitat, many wildlife species that are common to abundant in much of the province are rare. Examples include Black-capped Chickadee and White-breasted Nuthatch (Oldham, 1983).

Table 2.4 summarizes the number of breeding forest-associated birds in five areas with varying amounts of forest cover. The total number of species present is compared to the number of species that should occur, based on broad geographic ranges. As the top third of the table indicates, 100% of the species that should occur are present in Ottawa-Carleton, which is approximately 30% forested. In contrast, Essex (at 3% forest cover) has lost almost 40% of its forest birds. The Ontario Breeding Bird Atlas results (Cadman et al. 1987) were used to determine the number of forest-dependent bird species in municipalities with varying amounts of forest cover.

2.2.2 Size of Largest Forest Patch

Robbins et al (1989) determined habitat area requirements for forest birds in the mid-Atlantic states. Almost all of the bird species they documented occurred at least occasionally in forests 100ha or smaller; the few they did not find in forests this small have been confirmed breeding in southern Ontario forests 100ha in area or smaller. However, 100ha is considered an extreme minimal target for forest patch size. Many of the true forest-interior species are rare in forests this small; the probability of detecting some of these species in 100ha forests is as low as 20 to 30% (Robbins et al,

1989). For a forest to be truly viable for forest -dependent birds, 1000-3000 ha may be necessary. In other words, the larger an area is, the more species it will support. This has been demonstrated for plants, invertebrates, fish and other wildlife species.

Table 2.3 summarizes some of the relationships between wildlife and size for forest, marsh and grassland habitat. It should be noted that birds use certain different sizes of forests in different geographical locations. Factors such as forest shape and proximity to adjacent forests, combine with forest size to give birds a better chance of avoiding excessive predation and achieving breeding success.

Table 2.3. Wildlife Use of Various-Sized Habitats

Patch Size (ha)	Forest	Marsh	Grassland and Savannah
1	♦ common mammals (grey squirrel) ♦ common birds (Blue Jay, American Crow) ♦ a few forest birds (Black-capped Chickadee, Eastern Wood Pewee, Common Grackle)	♦ small populations of muskrat ♦ common birds (Red-winged Blackbird, Canada Goose, Mallard) ♦ common amphibian and turtle species	♦ a variety of wildlife generalist species, none of which are dependent on grasslands
4	♦ may support a very few common edge birds (Downy Woodpecker, Great Crested Flycatcher) ♦ Eastern Chipmunk may be present	♦ similar species as above, but may also support Bullfrog	♦ some common grassland species may be present (Meadow Vole, Short-tailed Shrew)
10	♦ still dominated by edge species ♦ may have very small areas of interior and support numbers of forest interior and edge (FIE) i.e. Hairy Woodpecker, White-breasted Nuthatch ♦ may be large enough to support some species of salamander	♦ may support Black Tern, American Widgeon, Marsh Wren	♦ may support some common grassland birds (Savannah Sparrow, Eastern Meadowlark)

Table 2.3. Wildlife Use of Various-Sized Habitats

Patch Size (ha)	Forest	Marsh	Grassland and Savannah
30	♦ may support very small populations (1-2 pr) of forest interior (FI) i.e. Winter Wren, Brown Creeper, Black-and-white Warbler ♦ must be circular in shape, providing maximum interior habitat possible for size ♦ area-sensitive species (Veery) may be present	♦ may support similar marsh bird species as above	♦ supports most Ontario grassland mammals and a few more bird species (Upland Sandpiper, Bobolink)
50-75	♦ still predominantly edge, but will support small populations of most birds except those with very large home ranges	♦ Osprey may be present in marshes of this size	♦ more bird species (Northern Harrier, Short-eared Owl)
100	♦ may support all forest-dependent bird species ♦ many will still be in low numbers and may be absent if there is no nearby suitable habitat ♦ Woodland Jumping Mouse may be present	♦ may support small numbers of diving ducks (Redhead, Canvasback, Ruddy Duck)	♦ may support grasslands dependent Henslow's Sparrow
1,000	♦ suitable for almost all forest birds ♦ some forest-dependent mammals present, but most still absent	♦ supports all marsh species, although some may still have small populations	♦ supports almost all grassland species, but may still be inadequate for Sharp-tailed Grouse and Greater Prairie-Chicken
10,000	♦ almost fully functional ecosystem, but may be inadequate for a few mammals (100,000 ha has been suggested as a minimum)	♦ fully functional ecosystem	♦ minimum size for a totally functional ecosystem but some species may be near their minimum viable population level

2.2.3 Percent of Watershed that is Forest Cover 100m and 200m from Edge

In a southern Ontario study, Sandilands and Hounsell (1994) determined that certain bird species avoided forest edges when they were breeding. One guild (or group) of species typically nested 100m or farther from edge while a second guild nested 200m or farther from edge.

A minimum width of 500m is important in defining the ability of a forest to support forest-interior species. Because, true forest-interior species tend to nest 200m from edge, a forest width of 500m provides a 100m wide band of habitat for these species. Large forests that are shaped like a square or rectangle and are fragmented are suboptimal habitat for forest-interior species.

The next two portions of the table summarize the forest-interior and edge (FIE), and forest interior (FI) species that are most affected by a decline in forest cover. Forest-interior and edge species tend to nest inside forests, and a high proportion of them nest 100 m or farther from forest edge. Forest-interior species are deep woods species which usually nest 200 m or farther from edge. Note that when forest cover declines to around 15%, 20 to 25% of FIE and FI species disappear. An exception is Haldimand-Norfolk, which continues to support a high percentage of forest-breeding birds. This is because it contains several large (1000 ha) forests in relatively close proximity. In a landscape with a low percentage of forest cover, habitat patches must be large enough to support several pairs to prevent extirpation i.e. in Ottawa-Carleton, Hairy Woodpeckers may be found in woodlots 10 ha or even smaller; in the Town of Markham (5% forested) none were found, although some woodlots approached 100 ha in area. In Essex County, only about 50% of FIE and FI species combined remain, and 80% of the FI species have disappeared. Landscape richness is a concept that considers the spatial distribution, quality and diversity of habitats. A healthy landscape has representation of all natural habitats that occurred historically, and they are well connected to adjacent habitat types. Not only should a wide range of habitats be represented in a landscape or study area, a range of successional stages of each habitat should be present. Each habitat and each age class of habitat has the potential to support different plant and wildlife species. Rich landscapes enhance biodiversity, and buffer the effects of natural catastrophes like diseases or insect infestations.

The overall effect of a decrease in forest cover on birds is that certain species disappear and many of the remaining ones become rare. Species with specialized habitat requirements are most likely to be adversely affected. Although little data exists for other groups of species, the effects of declining forest habitat likely affects other forest dependent species such as salamanders, tree frogs, and many mammals.

Table 2.4. Number of Forest-Associated Bird Species in Five Areas of Southern Ontario with Differing Percentages of Forest Cover (Adjusted for Potential Breeding Ranges Based on Presettlement Habitat)

	Ottawa-Carleton	Haldimand-Norfolk	Waterloo-Wellington	Middlesex	Essex
Percent Forest Cover	29.4	16.2	14.8-18.2	13.5	3.0
Total number of Species within Range	94	102	100	102	102
Number of Species Occurring	94	98	88	83	63
Percent of Total Potential Species Present	100.0	96.1	88.0	81.5	61.7
Number of FIE and FI Species Present	60	62	54	50	36
Number of FIE and FI within Range	60	66	64	61	66
Percent of FIE and FI Species Present	100.0	93.9	84.4	82.0	54.5
Number of FI Species Present	18	19	15	16	4
Total FI Species Within Range	18	20	20	20	20
Percent of FI Species Present	100.0	95.0	75.0	80.0	20.0

FIE Forest Interior and Edge
FI Forest Interior

Source: Cadman et al. (1987); Riley and Mohr (1994)

2.2.4 Percent of First to Third Order Streams that are a) 75% Vegetated and b) have 30m Wide Buffers

Stream order is a measure of the position of a stream or river in the hierarchy of the tributaries which make up the watershed. First order streams are headwater streams which do not have any tributaries. Second order streams are those which have only first order streams as tributaries. Third order streams start below the confluence of second order tributaries, and so on (Figure 2.1). In general, the higher the order, the larger the stream or river. In Ontario most drainage systems rarely have in excess of a fourth or fifth order stream prior to emptying into one of the Great Lakes.

As the order of a stream increases the flow and width increases. Small headwater streams are generally of orders 1-3, and highly dependant upon vegetation cover for their coldwater character. Small coldwater streams largely rely upon input of organic matter from adjacent vegetation (falling insects, leaf matter) for production. Stream gradient is generally greater in lower order (1-3) streams which often indicates higher erosion potential if riparian vegetation is removed. As stream order increases there is greater in-stream productivity and there is a transition from a stream dominated by terrestrial vegetation to one dominated by internal production. Higher order streams generally have a lower gradient with correspondingly deeper, slower moving water flows. Deposition of suspended sediments may be significant in some locations.

The characteristics of lower order streams (1-3) make them much more dependant upon riparian vegetation and buffer strips for protection of natural ecological functions. From a watershed perspective, planting vegetation along streams of orders 1-3 will produce greater benefits than planting along higher order rivers. Vegetation along a smaller stream has better potential to provide sufficient cover to lower summer maximum stream temperatures than along the banks of a large river. However, other habitat benefits can be realized from planting along the shorelines of large rivers and lakes and should not be ignored.

Seventy-five per cent Vegetative Cover

In a Toronto area study, stream degradation occurred when riparian vegetation amounted to less than 75% cover along stream courses (Steedman, 1987). This is consistent with the target of 75% for the Rouge River watershed in the Metro Toronto AOC outlined below. Although the example given here is derived from a Metro Toronto situation, the target of 75% riparian vegetation cover should apply to all AOC watersheds.

Rouge River Example

The MTRCA recently completed a study of the Rouge River drainage system, termed the Forested Watersheds Study which analysed watercourses by order and amount of riparian vegetation. This information will be used to guide habitat restoration and reforestation efforts (Strus et. al. 1995). Summarized below are the amounts of stream/river by order with riparian vegetation on either side of the stream (modified from Strus et.al 1995).

Non-Forested Streams

Stream Order	Area (ha)	Length (km)	% Forested
1st	1216	202	18
2nd	483	80	33
3rd	211	35	41
Other	691	115	40
Total	**2601**	**432**	

The habitat targets for the Rouge River watershed include a 30 m buffer strip along 75% of stream length. A threshold of fish community degradation in Toronto area streams was defined when less than 75% vegetated cover remained in riparian lands. From the table above, it is apparent that none of the stream groups examined have 75% forest cover. To achieve the best benefit for rehabilitation effort, priority will be given to first order streams. For more information on this technique, please contact Chris Gurstencorn at the MTRCA at (416) 661-6600.

30m Buffer Strip Width

The width of a buffer strip required to provide protection along a watercourse is site specific, but some general guidance is offered in various documents. The Ontario Ministry of Natural Resources (OMNR) has developed guidelines on the use of vegetative buffer strips along stream banks to provide shade to the watercourse and also to reduce erosion and increase bank stability (OMNR 1987; 1994). The OMNR suggests that warmwater streams be protected by buffer strips 15 m in width, while coldwater streams require a 30m buffer.

Proposed changes to the Ontario Planning Act (currently under review) suggest a 30m distance as a guideline for planning development near shorelines. Elsewhere, in small coldwater streams, buffer widths of six times the full channel width have been suggested as sufficient to shade small streams (O'Laughlin and Belt 1995). For a two metre wide salmonid stream this would translate into a 12m wide buffer strip. This may be sufficient to provide the necessary shading and bank protection. However, adjacent land use must also be taken into consideration to ensure that natural surface runoff and groundwater regimes are not interrupted.

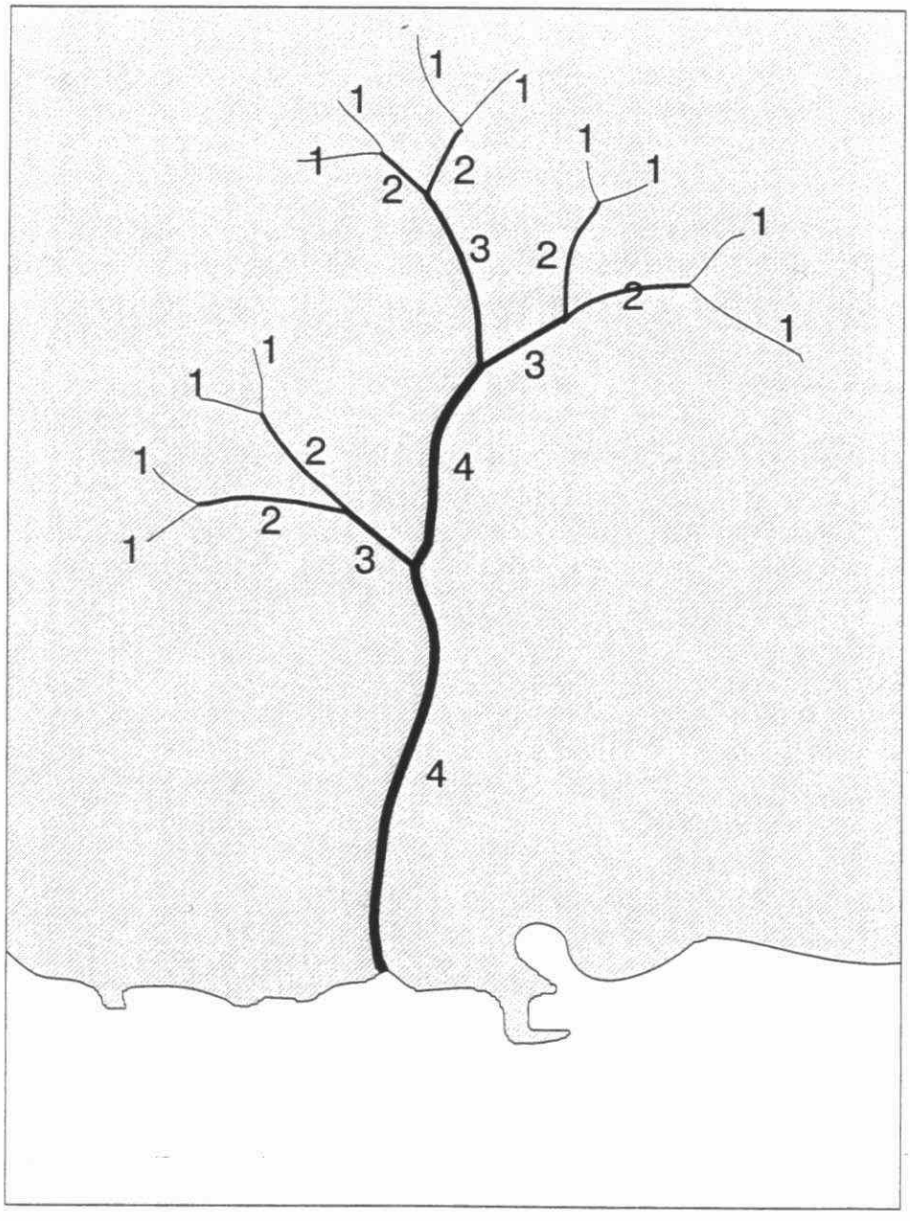


Figure 2.1 Stream Order of a Watershed System

2.2.6 Percent of the Watershed that is Impervious

Snodgrass (1992) reported that water quality became degraded when the threshold of development reached 15 to 25% of the watershed, and that even state-of-the-art management could not prevent impairment. Schueler (1994) reports on a number of studies that relate imperviousness to runoff characteristics, the shape of streams, water quality, pollutant loading, stream warming, and stream biodiversity. In his review he suggests 10% total impervious cover as a target to protect stressed streams. A target of less than 15% imperviousness should maintain stream water quality, quantity and biodiversity relatively unimpaired.

2.3 RELATED ECOLOGICAL FACTORS THAT ARE DIFFICULT TO MEASURE THROUGH TARGET SETTING BUT AFFECT HOW BIRDS AND OTHER WILDLIFE SPECIES USE FORESTED LANDSCAPES

2.3.1 Habitat Shape and Proximity to Other Areas

Habitat shape is as important as size. Areas with high interspersion and edge favour common generalist species as opposed to the more uncommon specialists. Figure 2.2 demonstrates how habitat shape influences the amount of interior habitat. Square or circular habitats provide the greatest amounts of interior, while similarly-sized linear or irregularly-shaped habitats may contain little or no interior.

Habitats in close proximity to other natural areas support more species than isolated habitats of the same size. Some species with large home ranges may use several patches instead of one large area. Close proximity of habitats also facilitates wildlife movements between them. When rehabilitating habitats, improving the shape of existing habitats and focusing on areas that are near other natural areas will be most effective.

2.3.2 Fragmented Landscapes and the Role of Corridors

Corridors linking habitat areas are an important part of a natural heritage strategy. All existing corridors should be maintained but caution is required when establishing new corridors. There may be positive and negative aspects to new corridors.

When considering establishing a new corridor, it is important to know what species are likely to use it and also what species are present in the habitats that will be linked. Narrow corridors (< 10 m) are used primarily by predatory mammals such as raccoons and skunks. A new corridor may funnel them into important habitats and reduce the reproductive success of more sensitive species. On the other hand, wide (> 100 m) corridors may provide habitat for specialist species and facilitate their movement through the landscape.

Riparian corridors are the most valuable and rehabilitation efforts in the AOCs should focus on them. Not only are they widely used by wildlife, they provide direct benefits to aquatic habitat. When establishing riparian corridors, it has been recommended that the entire floodplain be allowed to

revegetate, as well as a continuous corridor on at least one side of the valley that is at least 100 m wide.

In upland areas, an alternative to creating corridors is to create more habitat patches. A mosaic of patches has some advantages in that it does not provide a direct travel way for predators or a conduit for natural disasters such as fire and disease. In all cases, enlarging or infilling (planting an open patch inside an existing forest patch) existing forests is a preferred habitat rehabilitation technique.

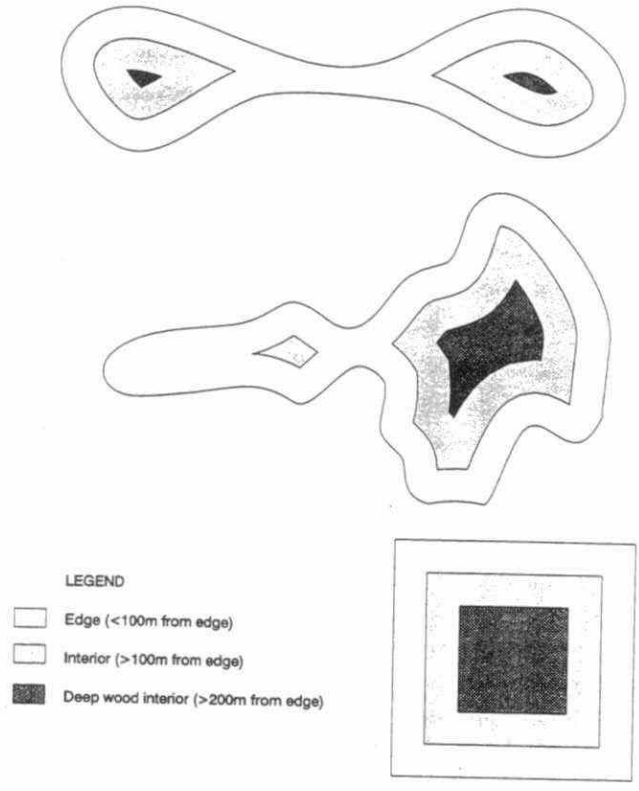


Figure 2.2. Forest Shape Determines Amount of Interior Habitat

3. STEPS FOR IDENTIFYING HABITAT REHABILITATION PRIORITIES: MAPPING TECHNIQUES AND ECOLOGICAL ANALYSIS

3.1 Map Scale

Before venturing too far in describing the types of data available it is worth briefly discussing the issue of scale in maps. Although map scale is obvious to some people, often only experienced practitioners can readily comprehend the implications of map scale. Scale has the meaning of a ratio, and is generally indicated by the length used on a map to represent an actual distance on the ground. For example, a scale of 1:100,000 means that 1 cm on a map represents 1 km on the ground. On older maps, a scale of 1:63,360 represents 1 inch on a map to 1 mile on the ground. Scale can also be expressed as a fraction where 1 inch would represent the numerator, and 63,360 the denominator (eg. 1/63,360).

The terms "large" and "small" scale maps is sometimes a point of confusion. Large scale maps have a small denominator, and have potential for more detail per square map unit. On the other hand, small scale maps have a large denominator with less potential for detail per square map unit. Thus, a large scale map of 1:10,000 contains much more detail than a small scale map of 1:250,000. On the other hand, the small scale map covers a much broader geographic range on the ground.

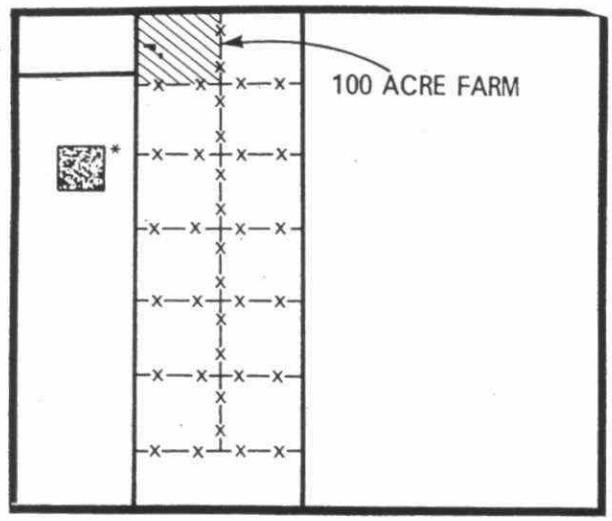
This latter point is illustrated by considering the example of map coverage of the Ontario Ministry of Natural Resources Fonthill Area. The Fonthill area is easily covered by one small scale map of 1:250,000. However, it requires parts of at least 8 National Topographic Series (NTS) maps at 1:50,000 to cover the same region. Furthermore, it requires 171 Ontario Base Maps (OBMs) at a scale of 1:10,000 to cover the same region. The logistics of data organization and map handling must be taken into account when considering what map scale to work at.

The other issue to be recognized is that the relative error due to scale increases from large to small scale maps. This is important to recognize especially in these days of photocopying machines able to enlarge and reduce maps. Accuracy is decreased when enlarging a map from 1:100,000 to 1:10,000 because errors will be magnified.

It is important that the map scale should be equal or greater than the scale at which decisions are made (Richards et al. 1979). Table 3.1 illustrates some general scale relations between ground distance and the standard minimum mappable area. For example, at a scale of 1:50,000, the approximate minimum mappable area is 10 ha (25 acres). Thus, if the purpose of a habitat mapping exercise is to identify and map all woodlots of 5 ha and greater, then a minimum scale of 1:25,000 is required. At the larger scale of 1:10,000, woodlots 0.4 ha (1 acre) would be distinguishable (Figure 3.1).

Highway
Farm boundary
Buildings
Trees

As scale decreases (gets smaller), the amount of information per unit of ground area shown on the map decreases and the area covered per square map unit increases. As scale increases (gets larger), the opposite is true.

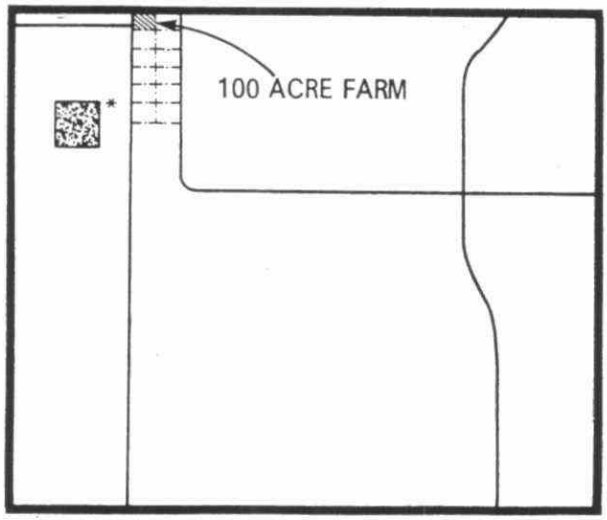


0 2 Km Bar scale

1 mm ≡ 63.36 m (208 ft)

40 mm^2 ≡ 16 ha (40 ac)

1:250,000

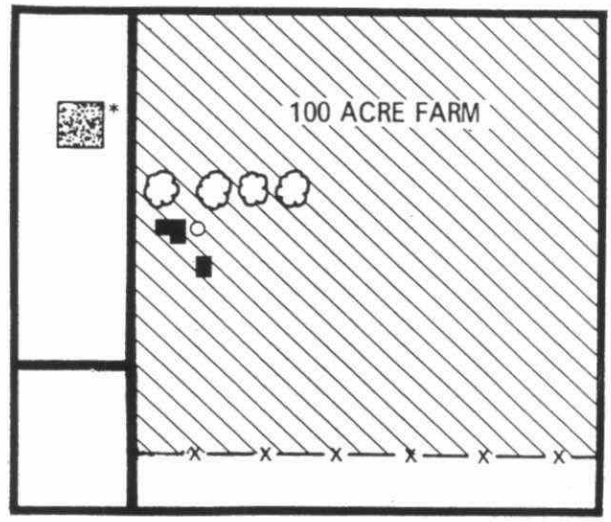


0 5 Km Bar scale

1 mm ≡ 250 m (812 ft)

40 mm^2 ≡ 250 ha (620 ac)

1:10,000



*Minimum legible map area (40mm^2),

0 ½ Km Bar scale

1 mm ≡ 10 m (32 ft)

40 mm^2 ≡ 0.4 ha (1 ac)

Figure 3.1. Relationship of Scale to Ground Area and Degree of Detail

Table 3.1 Scale Relations

Map Scale	Ground Distance Represented by 1mm Map Line		Minimum Mappable Area (40 mm^2 on map)	
	Metres	Feet	Hectares	Acres
1:1,000,000	1,000	3,250	4,000	9,900
1:500,000	500	1,625	1,000	2,500
1:250,000	250	812	250	620
1:126,720	126.7	415.8	64.8	160
1:125,000	125	400	62.5	150
1:63,360	63.4	208	16	40
1:50,000	50	160	10	25
1:25,000	25	80	2.5	6
1:10,000	10	32	0.4	1
1:5,000	5	16	0.1	0.25

Source: Richards *et al.* (1979)

3.2 Mapping Methods: Geographic Information Systems (GIS) vs. Non-GIS Mapping

In general, Computer Aided Design (CAD) and desk-top mapping programs produce high quality maps with some analytical capabilities, such as area and distance calculations. Preparing a drawing in CAD requires less time than a Geographic Information System (GIS). The output from CAD focuses primarily on the visual component whereas GIS provides database information associated with the drawing. GIS technology enables effective data analysis through area and distance calculations, overlaying functions, and digital terrain modelling. Vector data can easily be exchanged between these two systems through the GIS data conversion function.

Government agencies use GIS technology to aid in a multitude of tasks at both the federal and provincial level. There are numerous GIS software packages available each having their own strengths and weakness in performing various tasks. The Ministry of Natural Resources and Agriculture Canada primarily use the Arc Info software, whereas the Ministry of the Environment use SPANS GIS. Many conservation authorities purchased SPANS systems, but some are converting to PC ARC Info, or using both systems. However, data can be exchanged between the various types of GISs. Recently, RAP Steering Committee held a workshop on the use of GIS. A reference binder, Geographic Information Systems: A RAP Primer, holds a variety of information on GIS applications.

Many documents and reports continue to be produced using hand drawn maps in situations where maps are required for a one time use only. However, if maps are to be updated, thematic information produced for overlays, or detailed statistical and spatial analysis is to be carried out then GIS-based maps are required. In addition, GIS allows for electronic output for maps i.e. trend is towards providing maps on a compact disk or on the Internet. In terms of time and effort or cost for the different approaches there is no simple comparison. GIS software is relatively expensive to purchase (> $5,000.00 for basic program), and a person to effectively use the software requires at least a year of training. Various software programs are now available that allow interface between GIS and AutoCad programs to achieve greater flexibility in map output and data analysis.

For the extensive analytical work required in implementing the approach suggested in this document, a GIS is recommended. For further details please see the RAP Steering Committee binder, GIS: A RAP Primer forwarded to all RAP coordinators, December, 1995.

3.3 CREATING THE MAPPING TO TEST THE HABITAT TARGETS: A RECOMMENDED PROTOCOL

Mapping is a critical component of this strategy to document existing conditions, and to identify habitat rehabilitation needs and priorities. Mapping for the AOC habitat strategy is a five step process that should be accomplished at two complementary scales:

1. **It is suggested that all AOC-wide base data be gathered and mapped at a scale of 1:50,000, using National Topographic Series Mapping (NTS).**

2. **For detailed habitat analysis and rehabilitation project design, a larger scale of 1:10,000 (or 1:20,000 in the north) is recommended to provide sufficient detail to allow rehabilitation plans to be developed using Ontario Base Mapping (OBM).**

3.3.1 Data availability

There is a rapidly growing wealth of information available in map format for much of Ontario. Mapped data include soil classification, forest resource inventories, environmentally sensitive areas, wetlands and fish and wildlife habitat, to name but a few. This information is available in both hardcopy and electronic format. Some examples of digital data availability and sources are discussed below.

A critical component of conducting a habitat analysis is to gather all the appropriate and necessary mapped data. Information on ecological features is available from a variety of sources, many of which are overlapping. Furthermore, key information is often available at different scales which makes data consolidation a challenge.

For the types of information required for rehabilitating habitat in AOCs, the recommended primary types and sources of data include:

1. Natural Resources Canada

- Digital and paper copy National Topographic Series Maps - 1:50,000 scale

The NTS maps are produced at a scale of 1:25,000, 1:50,000, or 1:250,000 in either paper copy or digital format. The thematic information included is very similar to that on the OBM series (Table 3.1). Paper copy NTS maps are available from many local OMNR offices, local stationery stores, designated government book stores and from Geomatics Canada, part of Natural Resources Canada, Ottawa, K1A 0E9. Tel: (613) 592-7000. Digital maps are only available from Geomatics Canada at a cost of $540.00 per sheet.

2. Ontario Ministry of Natural Resources

- Digital and paper copy Ontario Base Maps - 1:10,000 scale

The Ontario Base Mapping Series (OBM) was first commissioned in 1972 to provide medium scale coverage of the entire province for dominant physical properties, natural resources and land use. Map coverage is at 1:20,000 for northern Ontario and 1:10,000 for southern Ontario. OBMs are available from the OMNR. More recently, OMNR has been given the mandate to digitize the base maps. Currently, one paper OBM copy costs approximately $7.50, while the same information in digital format costs $145.00 (including PST and GST). Digitizing the OBMs is still in process, therefore, availability of digital maps varies among regions. Table 3.2 below summarizes information on OBMs.

Table 3.2 Thematic Information Contained on Ontario Base Maps (OBMs) Themes (available from OMNR)

1. Vegetation	Wooded Areas
2. Hedge	Hedgerow Features
3. Drainage	Drainage System Features
4. Drain lines	Miscellaneous Drainage Lines
5. Drain points	Miscellaneous Drainage Points
6. Building	Scale Buildings
7. Pitpile	Pits and Piles
8. Cultlines	Miscellaneous Cultural Line Features
9. Cultpoints	Miscellaneous Cultural Point Features
10. Transport	Linear Transportation/Communication Features
11. Transp	Miscellaneous Transportation Features
12. Spots	Cartographic Spot Elevations
13. Town lines	Linear Township Fabric
14. Town points	Township Fabric Labels
15. Anno	Cartographic Annotation
16. DTM	Digital Terrain Model Data
17. Contour	Cartographic Contour Features
18. Names	Nameable Geographic Features

In the Niagara River AOC, digital OBMs are available in two different categories. The two categories (A and B) are digital OBM maps that have been supplemented with additional information. Category A includes digital layers for parameters such as deer trails, Wildlife Management Units, etc. Category B digital maps include evaluated wetlands. The cost for purchasing a digital Category A and B map is currently $490.00 and $290.00, respectively.

Other sources of data available from OMNR may include:

- Forest Resource Inventory Maps
- Natural Heritage Information Centre (computers with this species occurrence database are now in place in each OMNR district)
- Wetland data records
- Fisheries management plans
- Area of Natural and Scientific Interest data

3. Conservation Authorities
- Environmentally Significant Area information
- Other watershed mapping including floodplain mapping

4. Regional, County of Area Municipality
- Aerial Photographs
- Environmentally Significant Area information

5. Ontario Hydro
- Forest Interior Habitat Maps for most of Southern Ontario

6. Ontario Ministry of Agriculture, Food and Rural Affairs
- Soils mapping

A detailed list of data sources for AOCs is provided in Appendix C.

3.3.2 Steps for Upland Habitat Rehabilitation Priority Setting in AOCs

Note: Please review examples on how these steps have been implemented in the Nipigon Bay and Humber River Watershed of the Metro Toronto AOC contained in Appendix A. In addition, pilot tests of the strategy are being conducted in the Niagara River, and Hamilton Harbour AOCs. Further work is underway in the Humber River watershed to complete that pilot test. Changes will likely occur to this strategy following a review of these pilot test examples.

Step 1 - Site Analysis: building the base map and establishing the database

a) Establish a baseline map for the AOC by obtaining digitized National Topographic Service (NTS) mapping at a scale of 1:50,000 from Geomatics Canada.

b) Map the major land use classifications. In the Niagara River AOC pilot project 1994 Landsat Satellite imagery is being used for this purpose. Fifteen land cover classes (see table 3.3 below) were identified and imported into SPANS-GIS and converted for analysis. Additional information was obtained to assist in landcover classification and later spatial analysis including:

- 1994 air photos (Regional Municipality of Niagara)
- wetland data records (Ontario Ministry of Natural Resources)
- forest resource inventory data records (Ontario Ministry of Natural Resources)
- agricultural land use and drainage maps (Ontario Ministry of Agriculture, Food and Rural Affairs)
- local fisheries management plan (Ontario Ministry of Natural Resources)
- soil coverages (Ontario Ministry of Agriculture, Food and Rural Affairs)
- physiography (Ontario Ministry of Agriculture, Food and Rural Affairs)
- Area of Natural and Scientific Interest data records (Ontario Ministry of Natural Resources)
- Environmentally Sensitive Areas data (Niagara Peninsula Conservation Authority)
- Public Conservation Lands, parks and open spaces, Conservation Areas, Wildlife Management

areas, Migratory Bird Sanctuaries, Crown Game Preserves, Agreement Forests, etc. (Niagara Peninsula Conservation Authority and Ontario Ministry of Natural Resources)
- Conservation Value Forest database (Ontario Hydro)

Although not applied in the Niagara River AOC pilot project, other attributes such as location of recharge and discharge zones, and the nature of slopes are helpful to determine factors such as soil erosion and important hydrogeological areas. Depending upon project budget, staff expertise and availability of data, additional information could be added. For example, the Metro Toronto and Region Conservation Authority's (MTRCA) Humber River Watershed Natural Heritage System Pilot Project is making use of OMNR colour infra-red photography, and have developed digital terrain models for steep slope considerations (for more information contact Andy Robertson at MTRCA - 416-661-6600 ext. 205).

Table 3.3 Land Use Classes used in the Niagara River AOC GIS Pilot Test Project

#	Classes	Definition	For Example
1	Commercial, Institutional, Communications	Grouped based on high percentage of impervious ground cover which alters drainage patters and increases surface runoff	Businesses, schools, jails, airports, radio towers, and recreation facilities (racetracks)
2	Transportation	Transportation routes of all types	Roads, railway tracks
3	Recreational open space	Intensively managed parks (does not include natural parks such s provincial parks)	Urban parks, golf courses, cemeteries
4	Extraction	Areas where stone, rock or soil is being extracted from the land	Pits and quarries
5	Canals and Reservoirs	Human-made waterways and water storage facilities	Welland canal, hydro canals, and reservoirs
6	Industrial	Industrial buildings and facilities	Industrial buildings, public utilities (hydro plants or sewage treatment plants), agriculture-related buildings (grenhouses, fruit packing plants, wineries)
7	Residential	All household dwellings	Household dwellings

#	Classes	Definition	For Example
8	Wetlands	As defined by OMNR (1993)	Marshes, swamps, fens, bogs
9	Coniferous Forest	Vegetation dominated by relatively mature conifer assemblages	Natural forests, plantations
10	Deciduous Forest	Vegetation dominated by relatively mature deciduous assemblages	Natural forests
11	Mixed Forest	Vegetation dominated by relatively mature mixed assemblages	Natural forests
12	Water	All natural waterways	Natural ponds, streams, rivers, lakes
13	Scrub	Natural or regenerating areas that are dominated by vegetative ground cover or shrubs. Trees may exist on these lands, but are not the dominant vegetation type	Abandoned farmland, shrub-dominated areas, savannah, alvars
14.	High Intensity Agriculture	High intensity of land managment and pesticide use	Nursery stock operations, all grain crops, sod farms, orchard market gardening, tender fruit, vineyards
15	Low Intensity Agriculture	Lesser degree of land management and pesticide use	Hay, pasture, grazing land

c) Checking previously mapped data for accuracy

This step is very important. If the project should proceed with inaccurate mapped data, then the analysis that occurs in future steps will provide a false picture of habitat in the AOC. In the Niagara River AOC example, the land use classification obtained from Landsat imagery had to be checked and reclassified to more accurately represent forest cover found on the Niagara Peninsula. People familiar with the AOC will be a good resource to check the accuracy of the base map.

The 1:50,000 NTS maps, prepared in 1978, must be checked and edited to more accurately show the presence of streams (see box below). Also, in Niagara, streams had to be differentiated from irrigation and drainage canals through comparing 1:50,000 mapping with Ontario Ministry of Agriculture, Food

and Rural Affairs (OMAFR) drainage maps (note: although OMAFR drainage maps are of 1983 vintage, very few new drainage ditches have been constructed). The boundaries of individual habitats must be verified and updated by ground - truthing, or use of recent air photos usually at a scale of 1:8,000.

> A word of caution regarding "blue lines" on the NTS maps which represent watercourses. These must be ground -truthed for all lower order streams and tributaries. Many "blue lines" turn out to be drainage swales in the middle of a corn field or otherwise equally non-existent as potential fish habitat. The presence of larger streams and rivers is generally accurately mapped but smaller tributaries must be verified. This is especially important if priority is given to restoration of 1st and 2nd order streams.

Step 2 - Historical Plant and Animal analysis

It is important to gather historical vegetation and animal species lists to document the degree of landscape change that has occurred. AOC habitat targets can be revised if it is desirable to attract specific species. In some areas historical vegetation maps and animal species lists are not available, and this step cannot be completed. In these cases, the various wildlife atlases can be used to determine gaps in species distribution. The OMNR Natural heritage Information Centre (NHIC at 705-745-6767) has a database of species information which includes information from Ontario volunteer atlasing projects. From a review of the Ontario Herpetofaunal Summary database at NHIC, the Canadian Wildlife Service (CWS) has produced a technical report which includes a list of all reptiles and amphibians found in AOCs (Shirose and Bishop, 1995). The CWS report is a good example of how Atlas information can be used to determine which species are apparently absent but occur in the general geographic location. In addition, CWS is preparing a report summarizing all waterfowl census data in AOCs.

To guide rehabilitation plans, it may be helpful to obtain presettlement information by contacting the London archeology office of the Ministry of Culture, Tourism and Recreation (519-675-7742). Vegetation maps have been compiled for most of southwestern Ontario (St. Clair River, Detroit River, Niagara River, and Hamilton Harbour AOCs) based on the field notes of the original surveyors. The original surveyor's notes for most of Ontario can be reviewed at the Provincial Archives. Historical wildlife populations can be predicted using wildlife habitat matrices (DeGraaf and Rudis, 1986; Hounsell, 1989). Banfield (1974) summarized the status of the mammals of Canada and presented maps which also show historical distributions. Local naturalists' clubs, anglers, hunters and trappers are always a good source of species occurrence information.

Refer to Appendix A for how this step was implemented in the two Humber River sub-watershed examples. Appendix B provides a list of all species found in those sub-watersheds including identification of expected species that were missing.

Step 3 - Habitat Rehabilitation Project Identification and Design

When the base map has been corrected so that it reflects the habitat that is actually present on the ground, the GIS can be used to compare existing conditions in the AOC to the habitat targets provided in section two. Additionally, it becomes easier to see how the different types of habitat within the AOC watershed are arranged, thereby making it obvious where linking corridors can be created or enhanced, or forests expanded. Once it has been determined how the actual habitat conditions in the watershed compare to the targets, planning can begin to prioritize areas for habitat rehabilitation.

This step is iterative in that after every draft design, the plan must be assessed for its contribution to achieving the AOC habitat targets. All too often, it is tempting to try and restore the worst areas first. However, these areas are typically degraded because of several interacting factors and on-site efforts will fail if the upstream causes are not remedied. This can result in frustration for the rehabilitation team and a lack of public support. The following principles should serve to set priorities for habitat rehabilitation projects: **Protect the best areas that are currently in the AOC**. If these are lost, additional degradation will take place; **Expand the best areas by infilling open areas within or adjacent to forested lands**. This will undoubtedly have positive results. At the same time, the restoration team will learn what works and will gain confidence and public support; and **Rehabilitate, working gradually towards the worst areas**. You will be building on successes all the time and will be learning and gaining support as you go. Enhancement of the better areas will often result in improvement of the worst areas.

Step 4 - Implementation

This is where the real work begins. The strategy is presented to the appropriate agencies and planning groups. Landowners must be consulted as partners to the strategy for successful implementation. Detailed design begins at the 1:10,000 scale or larger. Specific rehabilitation techniques for individual areas are identified and put in place.

Step 5 - Monitoring

Monitoring is required to demonstrate that habitat rehabilitation projects have lead to improved ecological conditions. Protocols for monitoring are designed. Key ecological (or abiotic) indicators are selected and a schedule established. A monitoring program should be simple and consistent. The Wildlife Watchers community-based wildlife monitoring protocol prepared by the Canadian Wildlife Service and its partners can serve as a model. For example, a Forest Bird Monitoring Program route can be established to provide a baseline by which changes in the forest bird community can be measured as conditions improve as a result of habitat rehabilitation activities.

Note: Appendix One provides an example of how the approach described above was implemented in two AOCs: Nipigon Bay and the Humber River watershed in Metro Toronto.

SUMMARY

In the past decade, our understanding of how ecosystems function has led to a move away from an singular island of green approach towards a more holistic effort to plan on a landscape, eco-region, or watershed level. This change makes intuitive sense, but has been difficult to implement on the ground in planning strategies like municipal official plans and RAPs. Now, in the mid-1990s a critical mass of ecosystem knowledge and skill is emerging. New areas of science including landscape ecology and conservation biology combined with improved ways in which to see ecosystems using remote sensing and GIS provide opportunities for improving ecosystem protection and rehabilitation efforts.

RAPs being developed with the ecosystem approach as a fundamental tenet of their planning are in a logical position to lead the way in applying this new understanding to restore fish and wildlife habitat in Great Lakes basin watersheds. More so in southern Ontario AOCs, the high level of habitat alteration means that RAPs must prioritize rehabilitation efforts to make the best of use of time and money towards delisting the habitat beneficial use impairment. This document is designed to provide habitat targets and thresholds, along with a GIS-based methodology to guide the delisting process. A five step process for setting priorities for upland habitat rehabilitation in AOCs is summarized below:

Step One - Building the GIS Base Map	**Current state of habitat in the watershed**
Step Two - Historical Plant and Animal Analysis	**Note changes in species composition**
Step Three - Habitat Rehabilitation Design	**Setting priorities to restore towards targets**
Step Four - Implementation	**Making projects happen on the ground**
Step Five - Monitoring	**Species responses to habitat improvements**

As RAP planning teams and PACs continue their commitment towards delisting AOCs in the Great Lakes basin towards the year 2000 and beyond, improved ecological understanding and the use of planning tools like GIS should make decisions clearer on where habitat rehabilitation needs to occur and to what extent. The desired result should be a restored functioning system of fish and wildlife habitats throughout AOC watersheds.

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APPENDIX A. Testing the Interim Habitat in the Nipigon Bay and Metro Toronto (Humber River watershed) AOCs

TESTING THE STRATEGY IN THE NIPIGON BAY AOC

Introduction

The Nipigon Bay AOC is the most northern area of Lake Superior (see Figure A-1). The area is renowned worldwide for its coldwater fishery, particularly for brook trout. Water quality, benthic invertebrate populations and fish and wildlife habitat have become impaired due to point and non-point discharges of contaminants, water level and flow fluctuations, and historical timber harvesting practices.

The Nipigon River, which drains into Nipigon Bay, has a drainage areas of about 38,128 km^2 including the Ogoki Diversion. Lake Nipigon has a surface area of 4,500 km^2. The majority of the watershed is forest in various stages of maturity due to the extensive forestry programs within the area. The small communities of Nipigon and Red Rock are within the AOC.

This appendix briefly evaluates the Nipigon Bay AOC against the fish and wildlife habitat targets that are identified in Section Two of the main report.

THE HABITAT REHABILITATION STRATEGY

Strategy Initiation

Nipigon Bay was listed as an AOC in 1987. The RAP is well advanced, and the team consists of members from the Ontario Ministry of Natural Resources, Ontario Ministry of Environment and Energy, Canada Department of Fisheries and Oceans, and Environment Canada. Since 1989, there has also been a Public Advisory Committee (PAC). The PAC represents members from the public, Kama Point Camper's Association, Domtar Packaging Limited, Nipigon Bay Boat Tours, Ontario Hydro, the Town of Nipigon, the Red Rock Indian Band and the Red Rock Fish and Game Club.

Step 1 - Site Analysis

The watershed is over 90% naturally vegetated, predominantly by boreal forest ranging from mixed deciduous-coniferous types with luxuriant shrub undergrowth to floristically poor, single-dominant coniferous types. The structure and age of stands varies considerably due to disturbances such as fire and timber harvesting.

In addition to forest cover, the aquatic habitats support communities of aquatic submergents and marshes dominated by grasses, sedges or cattail. Other wetland communities include fens, bogs, mixed swamps, and black spruce swamps. There are also areas of exposed bedrock with very sparse vegetation, plus cliffs and talus slopes along the river.

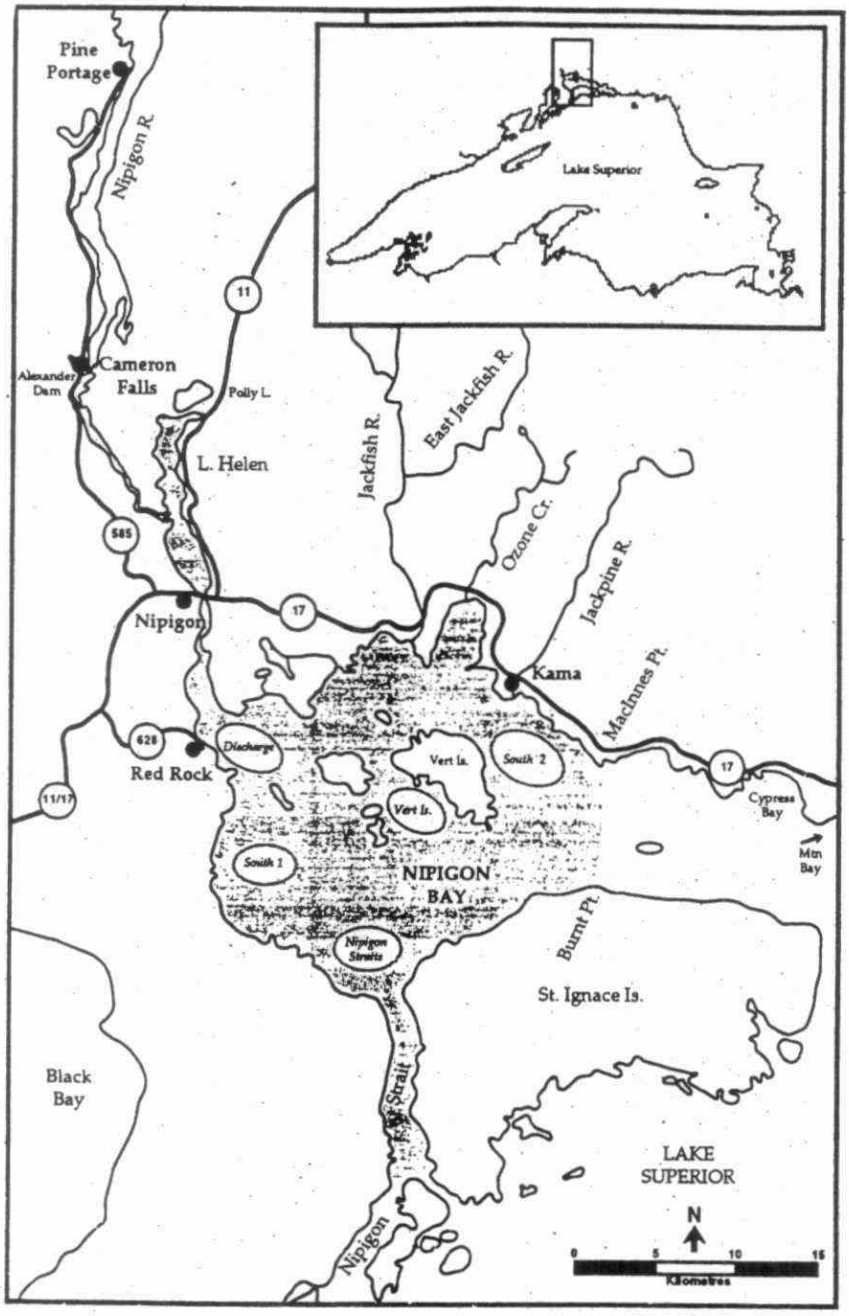


Figure A-1 The Nipigon Bay Area of Concern

A botanical study was completed along the Nipigon River from Pine Portage downstream to Red Rock in August of 1993 (Gore & Storrie Limited, 1994). Despite the lateness of the season and the fact that spring and early summer species may not have been evident, 359 plant species were documented. This is a high diversity of species for this latitude and the low percentage of introduced species indicates a healthy flora.

As would be expected, the majority of plant species present are boreal or widespread species. However, the high variety of microhabitats present also support species of arctic-alpine, southern and Lake Superior rock shoreline affinities. Eleven significant plant species were documented.

Because of the habitat diversity and extensive natural areas, the region also supports a greater diversity of wildlife species than normally occurs at this latitude. Since 1989, 159 bird species have been documented along the Nipigon River and 112 to 120 of these apparently breed in the area (Nipigon Bay RAP Team, 1995). Raptors and herons are common and increasing in the area. As they are at the top of the food chain, their abundance is indicative of a relatively pristine environment.

As many as 49 mammal species may occur within the AOC and 32 species have been documented recently. No mammal-trapping studies for smaller and hard-to-detect species have been completed lately.

From a plant and wildlife perspective, the AOC supports a high diversity of species and populations and communities appear to be healthy.

A total of 35 fish species have been documented from Nipigon Bay and its nearby tributaries. These include nine introduced species: sea lamprey, alewife, five salmon species, rainbow smelt, and carp. The bay itself has a relatively low diversity of fish species and the community is dominated by lake whitefish, common sucker, and longnose sucker. The tributaries are more diverse and support spawning populations of brook, rainbow and brown trout, Pacific salmon species, suckers and whitefish.

Water quality and benthic invertebrate populations have become impaired due to:

- water level and flow fluctuations due to operation of hydroelectric generating stations;
- discharge from a linerboard mill;
- discharges from the Nipigon and Red Rock Sewage Treatment Plants; and
- past usage of the Nipigon River for running logs. This resulted in scouring and damage to fish spawning areas and accumulation of bark and fibre deposits. Woody debris also accumulated in some shoreline marshes, possibly impairing wildlife habitat.

Step 2 - Historical Plant and Animal Analysis

This has already been completed as part of the Stage 2 RAP document and results are summarized below.

Vegetation communities have changed little historically, but there has been an increase in the proportion of deciduous forest. Originally forest succession was modified by fires, but early-succession areas are now created through forest management.

Forest management is much more sensitive to fish and wildlife populations than formerly. Originally, clearcuts were much larger and extended to the water's edge and logs were transported by water. Buffers are now left around all watercourses and water bodies, logs are transported over land and clearcuts are designed to maintain habitat for target species such as moose, deer, bear, pileated woodpecker and pine marten.

Avifaunal work conducted in 1923 and 1924 was compared to present conditions (Escott and Bryan, 1993). Since the original inventory, Great Blue Heron, American White Pelican (an endangered species) and Ring-billed Gull have colonized the area. Species that have significantly increased are loons, waterfowl, Herring Gull, Double-crested Cormorant, several species of large raptors, ravens and Evening Grosbeak. Species that have declined include Killdeer and a variety of other shorebirds and this may be due in part to the hydroelectric generating stations and lack of exposed mudflats. American Kestrel, Downy Woodpecker and Mourning Warbler also show evidence of decline.

Mammal populations do not appear to have changed much from historical conditions. Forestry operations resulted in more deciduous cover which resulted in a decrease in martens early in the 1900s. Their populations have remained stable or possibly have increased slightly since then. Forestry operations also created more edge which resulted in white-tailed deer moving into the area.

Fish populations have changed the most. The greatest factors have been sea lamprey predation, other exotic fish species, regulation of river flows and water levels, water quality impairment and physical alteration of habitat due to past forestry practices. Traditionally, brook trout, lake whitefish and more recently, walleye dominated the Nipigon River community, and these species have all been reduced. Other species that have been reduced or eliminated in the river are river-run lake trout, tulibee, lake sturgeon, sauger and slimy sculpin.

Step 3 - Habitat Rehabilitation Design
When the habitat of the AOC and its watershed are compared to the habitat targets in Table 2.1 of the main report, it is apparent that current conditions greatly exceed the targets.

From a natural heritage perspective, no work appears to be required in terrestrial habitats to improve fish and wildlife habitat. If the strategies outlined in the Nipigon Bay Stage 2 RAP document are implemented, delisting of this AOC should occur.

Step 4 - Implementation
No studies or projects need to be undertaken.

Step 5 - Monitoring
The only monitoring that is suggested is to ensure that existing conditions do not degrade. This can be accomplished through the forest management plans that will be prepared in the watershed. Proposed land use changes near the shoreline downstream of Lake Nipigon should be carefully examined to ensure that they do not have adverse effects.

THE HUMBER RIVER EXAMPLE: METRO TORONTO AOC

1. INTRODUCTION

The Metro Toronto and Region AOC is one of four AOCs on the Canadian side of Lake Ontario. It includes six major tributaries extending along the shoreline from Mississauga east to Pickering and northwards to the Oak Ridges Moraine. The main watercourses in the AOC are Etobicoke Creek, Mimico Creek, the Humber River, the Don River, Highland Creek and the Rouge River (Figure A-2)

The following use impairments have been identified in the Metro Toronto and Region AOC:

1. Restriction on fish and wildlife consumption. Local and lake-wide influences have resulted in accumulations of mercury, PCBs and mirex in fish and wildlife tissues.
2. Degradation of fish and wildlife populations with loss of species dating back to the 1800s and continued impacts due to on-going urbanization.
3. Degradation of benthic invertebrate populations. High densities of pollution-tolerant species occur in the lake, although some improvements have been noted recently.
4. Restrictions on dredging activities, with most sediments exceeding disposal guidelines.
5. Eutrophication. Phosphorus often exceeds desirable levels resulting in algal and weed problems.
6. Beach closings from bacterial contamination due to stormwater and combined sewer overflows.
7. Degradation of aesthetics due to debris and litter, water turbidity and aquatic weed growth.
8. Loss of fish and wildlife habitat has occurred historically and is continuing. Contamination of existing and newly-created habitat is a concern.

Rural and urban point and non-point sources have contributed to the degradation of the Metro Toronto and Region AOC. The primary problem sources are overland runoff from agricultural lands, streambank erosion, direct cattle access to streams, urban stormwater, combined sewer overflows (CSOs), and discharges from water pollution control plants (WPCPs).

Prior to settlement in the late 1700s, the watersheds draining into the AOC were almost entirely forested. By the 1880s, deforestation of the watersheds was complete: the rural landscape was an unbroken mosaic of cultivated fields and the City of Toronto supported a population of over 60,000. The lake was heavily polluted due to direct discharges of sewage and industrial wastes, and cholera outbreaks occurred frequently due to drinking contaminated water from the lake. Fish and wildlife habitat was greatly impaired prior to the 1900s due to deforestation and subsequent lowering of the water table, draining and filling in wetlands, lakefilling, and dredging of coastal gravel, rocks and boulders which depleted fish spawning shoals and reefs.

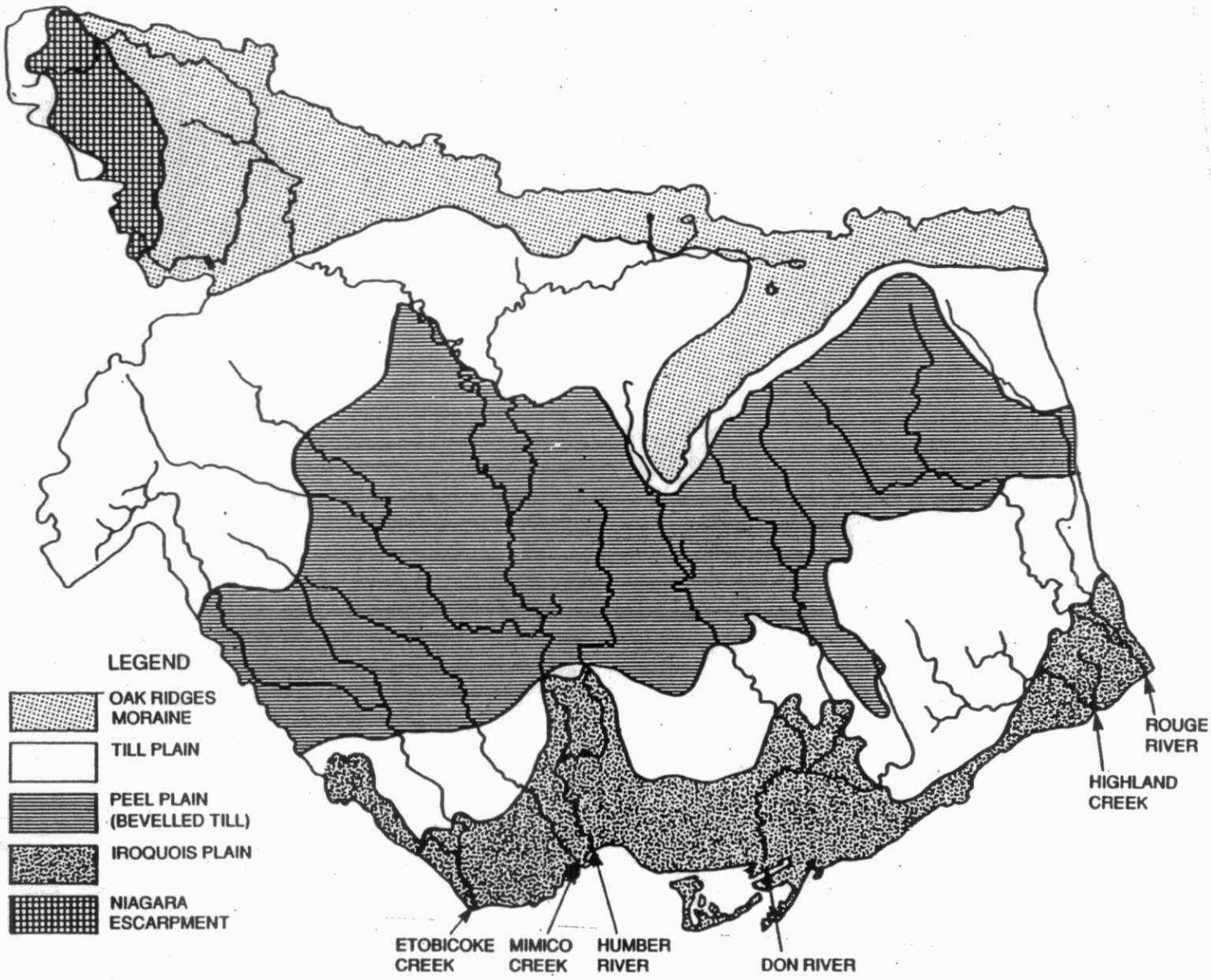


Figure A-2 The Metro Toronto and Area AOC

Conditions improved in the twentieth century due to construction and upgrading WPCPs, better stormwater management, reductions in industrial discharges, abandonment of some agricultural land allowing natural succession and active reforestation.

As part of the RAP, numerous initiatives have been made, with the majority of them focusing on the waterfront and problems emanating from urban areas. These have included improvements to existing stormwater management facilities and stricter requirements for new facilities, elimination of combined sewer overflows, improvements to WPCPs and improvements to existing fish and wildlife habitat as well as creation of new habitat (i.e. pike spawning areas, snake hibernacula, tern nesting platforms).

Work has also been conducted in the upper watersheds. This has included bank stabilization projects, fencing to restrict livestock access, buffer plantings along streams, and log cover structures. These projects are designed primarily to improve water quality and fish habitat; to date there has been limited effort applied to improving wildlife habitat away from the shoreline zone.

For the purposes of this example, we have selected two subwatersheds of the Humber River system. The Humber was chosen because:

1. MTRCA has compiled significant amounts of information. This includes a recently-released Watershed Atlas which provides an excellent history of the watershed and summary of its historical and existing resources. Most of the information essential to complete a natural heritage strategy has been compiled in GIS files by the Authority.
2. The Natural Heritage Subcommittee of the Humber Task Force is currently working toward a strategy for the watershed, so it was possible to benefit from their insights and knowledge of the watershed.
3. There are seven major subwatersheds in the Humber with very different characteristics and habitat limitations. Some include the more heavily forested areas of the Oak Ridges Moraine or Niagara Escarpment, others are in agricultural areas with limited tree cover, and others are predominantly urban in character. This allowed an opportunity to look at subwatersheds that had different types of problems due to their physiography and land use.
4. The Humber River is the largest watershed in the AOC, and therefore, is one of the significant problems. It is the largest single source of total suspended solids (TSS) to the Toronto waterfront, delivering 47% of the total loading of TSS. It has been estimated that rural non-point sources account for 85% of the TSS and 82% of the total phosphorus (TP) loadings in the Humber River.

By selecting the Humber River, it allowed us to demonstrate the effective use of GIS for improving habitat in two very different subwatersheds.

Overview of the Humber River Watershed

The Humber River watershed has an area of 908 km^2, with seven major subwatersheds. Approximately 46% of the watershed is agricultural, 24% is urbanized, 20% is rural and 10% is major open space. An additional 8% of the watershed is committed to development, which will result in 32% urbanization. Currently, 17% of the watershed is forested.

Originally, the streams in the watershed supported primarily Atlantic salmon and brook trout. With stresses such as deforestation, damming, and waste discharges, salmon were eliminated by 1898. Trout are now restricted to cold headwater streams, primarily on or at the base of the Oak Ridges Moraine.

The two subwatersheds that have been selected as examples are the Upper Main Humber and the West Humber:

- The Upper Main has an area of about 203 km^2. Its northeastern corner originates on the Niagara Escarpment, with most of it being on the Oak Ridges Moraine; the lower portion of the subwatershed is on the South Slope physiographic region. Urban centres in the subwatershed are Mono Mills, Palgrave, Caledon East and Bolton. The subwatershed is 41.6% forested.
- The West Humber subwatershed is also about 203 km^2 in area and it is situated on the South Slope and Peel Region physiographic regions. The majority of the subwatershed is agricultural land with Castlemore being the major urban centre. Extensive areas near Castlemore are committed to future development. The subwatershed is 6.7% forested.

The remainder of this appendix evaluates the Upper Main Humber and West Humber subwatersheds against the fish and wildlife habitat goals identified in Section Two of the main report. Conceptual strategies for improving habitat are presented for both subwatersheds.

2. HABITAT REHABILITATION STRATEGY FOR THE UPPER MAIN HUMBER SUBWATERSHED

Strategy Initiation

The Metro Toronto Remedial Action Plan was initiated in 1987. Environment Canada is the lead agency, but the RAP team is also comprised of the Ontario Ministry of Environment and Energy, the Ontario Ministry of Natural Resources, Metro Toronto and Region Conservation Authority (MTRCA), Metro Toronto, City of Etobicoke, City of Toronto, City of Scarborough, the Waterfront Regeneration Trust, and representatives of the Public Advisory Committee (PAC).

The PAC has been meeting monthly since March 1989. Sectors and interest groups represented on the PAC include agriculture, business, industry, community groups, individuals, education, environment, conservation, municipalities, recreation and tourism. Resource agencies in the PAC are Metro Toronto and Region Conservation Authority, Ontario Ministry of Environment and Energy, Toronto Harbour Commissioners and the Waterfront Regeneration Trust.

As part of the RAP team, there are also Scientific and Technical Advisory Committees (SAC and TAC). Members include Works, Environment, Health, and Planning Departments from the Region and local municipalities, Environment Canada, Ontario Ministry of Environment and Energy, Ontario Ministry of Natural Resources, Metro Toronto and Region Conservation Authority, Toronto Harbour Commissioners and PAC representatives.

The Humber Watershed is one of six included in the AOC. A Humber River Task Force has been established and MTRCA (1995) has published Phase 1 of the Humber River Watershed Atlas. The atlas documents current and historical cultural features and natural features within the watershed. A

variety of volunteer subcommittees have been established by MTRCA as part of the Humber River Task Force. The Natural Heritage System Subcommittee is charged with the task of designing a natural heritage system for the Humber watershed.

Step 1 - Site Analysis

As shown on Figure A-3, the subwatershed is more heavily forested (41.6%) than the watershed as a whole (17%). The entire subwatershed is in the Great Lakes - St. Lawrence Forest Region, which is dominated by upland deciduous tree species such as sugar maple, beech, red oak, basswood and white ash. Other common trees are hemlock, yellow birch, red and white pine, white elm, white cedar, aspen, white oak, white birch, black cherry, and butternut. Red and silver maple and black ash dominate lowland swamps. There are also isolated pockets of boreal habitat dominated by tamarack, black spruce, balsam fir, white cedar and yellow birch.

The subwatershed contains many significant habitats. There are three provincially significant wetlands (Centreville Creek Wetland Complex, Gibson Lake Wetland, Speersville Wetland Complex) that total 233.5 ha or 1.2% of the subwatershed.

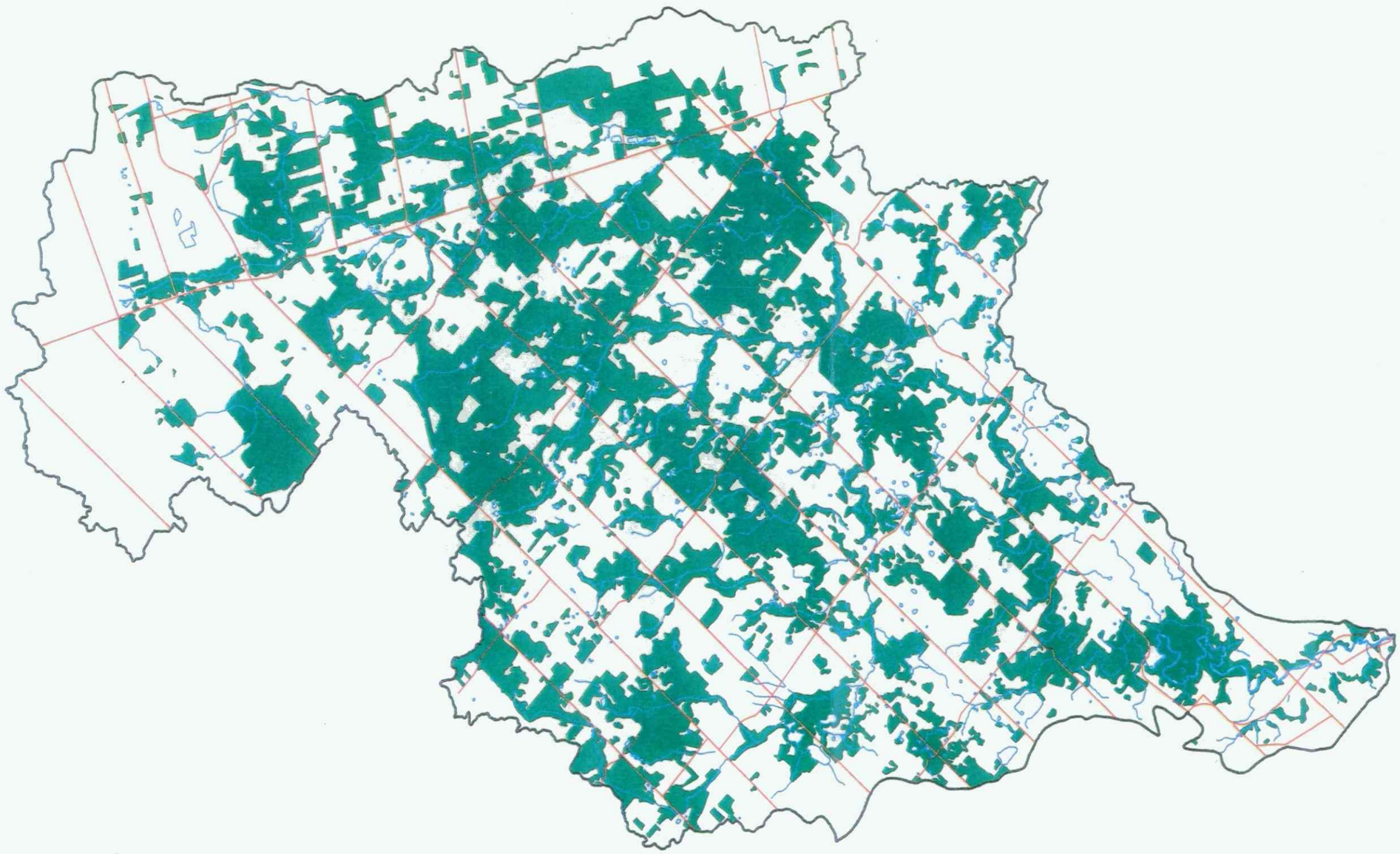
Nineteen sites in the subwatershed have been designated Environmentally Significant Areas (ESAs) by MTRCA. These total 2962 ha or 15.0% of the subwatershed. There is some overlap, in that one of the provincially significant wetlands is also an ESA.

Detailed inventories of plant and wildlife species have not been completed for the Humber River watershed or any of its subwatersheds. However, considerable information is available from ESA and ANSI studies, wetland evaluations, on-going inventories being conducted by MTRCA and the various provincial atlas programs.

For the purpose of the examples, we have used atlas data to provide an indication of the species that have recently been documented in the subwatersheds. The inventories being done by MTRCA could be used to refine this information. For fish, we have used the detailed data collected by Steedman (1987).

Table B.1 summarizes the fish species recorded in the two example subwatersheds. Eighteen native species occur in the Upper Main including some that are indicative of coldwater or good water quality (American brook lamprey, brook trout, mottled sculpin).

Tables B.2 and B.3 list the amphibians and reptiles found in the subwatersheds during the Ontario Herpetofaunal Summary. Like the other atlas programs, the purpose was to determine all species that occurred in every 10 x 10 km square in southern Ontario and every 100 x 100 km block in the north. Some caution is required in interpreting results. For the Upper Main, the entire subwatershed is contained fairly well in two atlas squares, so results are a reasonable indication of the species that are present. However, the West Humber is in three squares which also contain habitats outside of the subwatershed. Therefore, some of the species that have been documented may not occur in the subwatershed. Coverage for the Ontario Herpetofaunal Summary (OHS) has been reported only up to the end of 1986, so coverage was incomplete in many areas, particularly in the example



N

UPPER MAIN HUMBER SUBWATERSHED

Existing Forest Cover

Woodlots

Roads

Drainage

1000 0 1000 2000

Meters

Scale 1:80,000

Project Name:

STRATEGY FOR RESTORING FISH & WILDLIFE HABITAT IN THE GREAT LAKES AREAS OF CONCERN

Prepared For:

ENVIRONMENT CANADA

ENVIRONMENTAL CONSERVATION BRANCH

ECOLOGICAL SERVICES for PLANNING

Project: 95179

File Name: Upmain.map

Date: May 1995

Figure No.

A3

subwatersheds. More current information could be obtained from the OHS, the Environment Canada amphibian monitoring program, MTRCA's inventories and the Natural Heritage Information Centre.

Eight amphibian species have been documented in the subwatershed. The pickerel frog is usually associated with springs or other coldwater habitats, and the wood frog requires fairly extensive forests with breeding pools. According to the OHS, five common reptile species have been documented. The Humber River Atlas states that 17 amphibian and 14 reptile species currently inhabit the entire watershed.

Table B.4 summarizes the breeding bird species reported in the two subwatersheds by the Ontario Breeding Bird Atlas (OBBA). For southern Ontario, the OBBA gives a fairly accurate indication of species presence and absence. A total of 117 breeding bird species were documented in the Upper Main, including some forest-interior and wetland dependent species.

Table B.5 summarizes the species reported from the subwatersheds by the Ontario Mammal Atlas (OMA). The OMA relied primarily on agency records with limited input from volunteers. Many small mammals and species difficult to observe or identify were under-represented; in most squares, it is likely that more species are present than have been documented. Twenty-three mammal species have been observed in the Upper Main subwatershed including the snowshoe hare, which is usually associated with larger tracts of forest. In total, 40 species have been found in the entire Humber River watershed.

Step 2 - Historical Plant and Animal Analysis

The subwatershed was originally about 95% forested with the same tree species that are currently present. As a result of deforestation, several large mammals were extirpated from the Humber River watershed as a whole. These include gray wolf, lynx, cougar, wolverine, marten, fisher and black bear.

Table B.6 is a list of native fish and wildlife species that are apparently absent from the Upper Main subwatershed. This list was derived by looking at the atlases to determine species that are present in the general geographic area, but absent in the subwatershed. Species with sporadic distributions, such as mockingbird, were not listed. Some of the species may actually be present but unreported because of difficulty finding or identifying them.

Twenty-five species are listed in Table B.6, and 16 of these appear to be absent. They include 3 fish, 11 breeding bird and 2 mammal species. The missing fish are usually found in cold or cool water; the redside dace requires clear streams with overhanging riparian vegetation and the rainbow darter is often present in gravelly trout streams. The missing birds are either associated with extensive forests or marshes. Some of the forest birds (Blackburnian Warbler, Pine Siskin) prefer coniferous trees. The two mammals may have been overlooked, but the woodland jumping mouse is usually restricted to larger forests.

The method of using atlas data gives more meaningful information then attempting to predict presettlement wildlife populations. By identifying the current species present and those that are absent

but within the same geographic area, it is possible to estimate which species could potentially be attracted by a habitat restoration project. It also allows managers to determine the specific habitat requirements of target species or guilds and thereby focus the restoration strategy.

For the example subwatershed, lists of all species present were prepared in addition to the list of absent species. The inventory lists are useful as they can be used to identify species that could benefit from habitat restoration. However, the lists could be shortened by leaving off introduced species and abundant, generalist species. Then the list would be comprised of specialist species that require specific habitats or groups of plant species, wetlands, large grasslands or extensive forests (i.e. indicator species or those which would benefit most from restoration). These species are indicated on Tables B.1 through B.7.

Step 3 - Habitat Rehabilitation Design

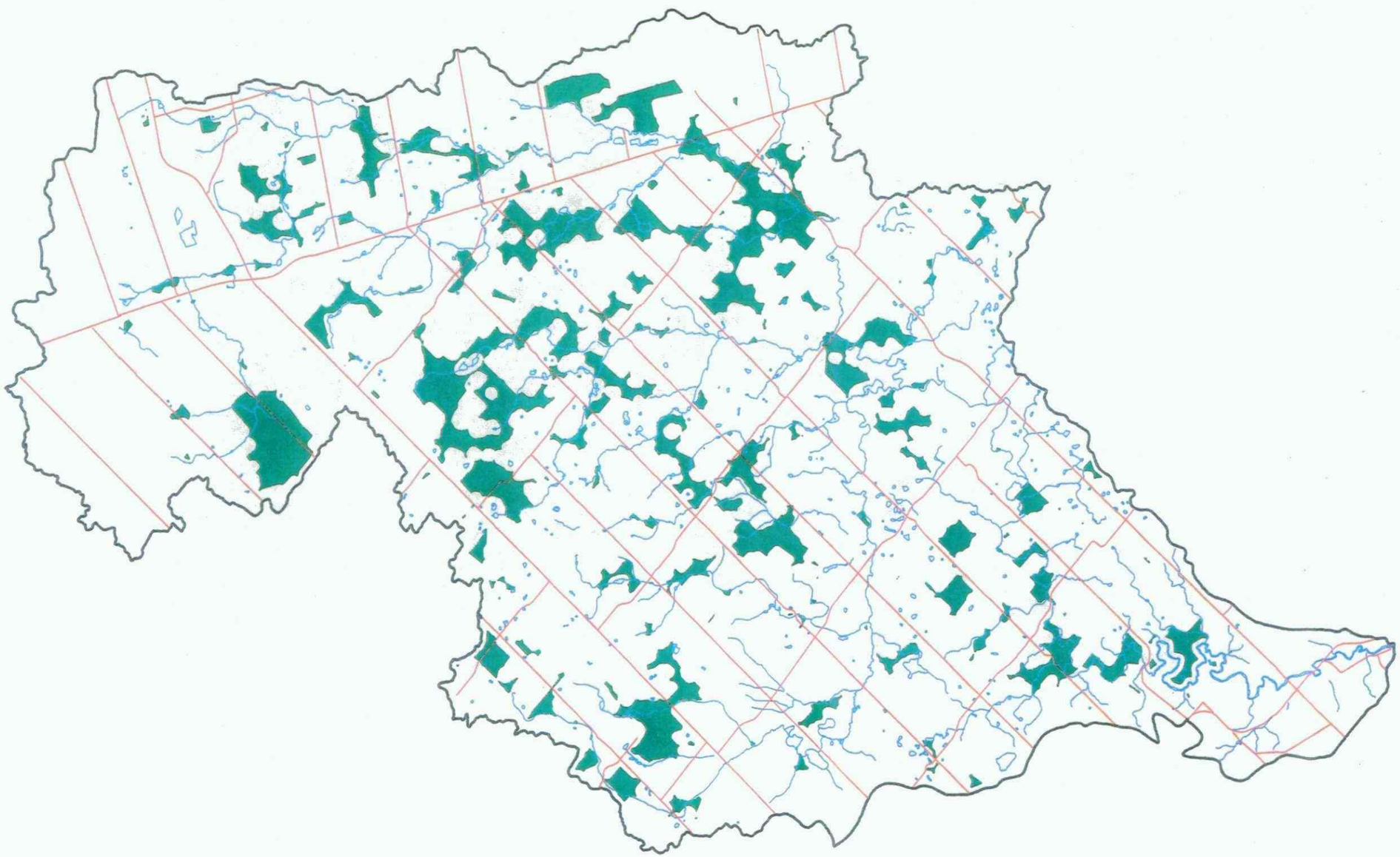
Table B.8 compares the features of the two example subwatersheds to the natural heritage goals. Before this comparison is discussed, a brief overview of the methods used to obtain the numbers is presented.

The percent forest cover was determined by first entering the outlines of woodlots and wetlands into GIS, using the data on the 1:50,000 NTS maps. When actually preparing a natural heritage strategy, the information on the topographical maps should be updated using aerial photography or OBMs. In addition, grasslands and old field habitats should be included, preferably on a different layer. The GIS was then used to calculate the area of natural habitats and of the subwatershed. If data are not available in GIS or AutoCad format, the calculations could be done manually using a planimeter. This is time consuming and less accurate, particularly when measuring either very large or very small areas.

The largest forest patch was calculated using GIS. When considering the outer boundary of a patch, natural areas separated by more than 50 m or by a paved road should be considered distinct patches. These are sufficient to create an edge effect for birds and a barrier for movement of amphibians, reptiles and small mammal species.

The percent forest cover 100 and 200 m from edge was calculated on GIS by applying buffers inside each forest patch (see Figures A-3 and A-4). For our examples, we ignored roads, railways and hydro and pipeline corridors and buffered around the outside perimeter of the woodlot. This overestimates the actual amount of forest interior. To obtain a more accurate figure for forest interior, the buffer should be applied from all features that result in forest fragmentation.e length of stream in a watershed and the amount of it that is forested or has an adequate buffer can be determined by GIS. Depending on the complexity of the watershed, this can be a fairly time-consuming task. An alternative is to use a map measurer to measure distances manually. This is considerably less accurate, but takes only a few minutes and is adequate for calculating approximate percentages.

The calculation of the amount of a watershed that is pervious is relatively simple. First, using GIS calculate the amount of urban development in the watershed. Then multiply this figure by 75% to obtain an approximate figure of how much area is hard surfaced or impervious. If the data are readily



N

UPPER MAIN HUMBER
SUBWATERSHED

Existing 100 Metre Buffer
from Forest Edge

Woodlots

Roads

Drainage

1000 0 1000 2000
Meters

Scale 1:80,000

Project Name:
STRATEGY FOR RESTORING
FISH & WILDLIFE HABITAT
IN THE GREAT LAKES
AREAS OF CONCERN

Prepared For:
ENVIRONMENT CANADA
ENVIRONMENTAL CONSERVATION
BRANCH

ECOLOGICAL SERVICES for PLANNING

Project: 95179

File Name: C3.map

Date: May 1995

Figure No.

A4

available and you want to be more precise on the degree of imperviousness in an urban area, use the following numbers:

downtown business areas - 95% impervious
neighbourhood business areas - 70%
single-family areas - 50%
detached multiunits - 60%
attached multiunits - 75%
apartments - 70%
light industrial - 80%
heavy industrial - 90%
estate residential - 30%

After this has been done, add another 2% of imperviousness to account for roads, railways, and individual dwellings and buildings in rural areas.

As indicated in Table B.8, the Upper Main subwatershed exceeds the natural heritage goals. Thus, it would be tempting to say that the strategy could be to simply maintain existing natural areas without doing any rehabilitation. However, additional improvements should be considered in the subwatershed because:

- it is part of a larger watershed which does not meet the goals
- much of it is part of the Oak Ridges Moraine, which is a significant source of baseflow to the entire watershed
- because it is the best quality subwatershed, there are excellent opportunities for significant enhancement (remembering the basic philosophy of improving the best areas)
- there are some small local problems in the subwatershed that should be rectified
- there are significant tracts of publicly-owned land where rehabilitation can be undertaken relatively inexpensively
- additional development is committed that will decrease the amount of perviousness from 93.8 to 89.1%, which is getting closer to the threshold of 85%

The first strategy is to identify sites that can be naturalized. By doing this, the following can be achieved:

- increasing the percent forest cover
- increasing the size of the largest forest patch
- increasing the amount of forest interior

In determining areas that have potential for naturalization, the following was considered:

- public versus private land as indicated in the Humber River Watershed Atlas
- sites where fragmentation was obvious
- presence of buildings, roads, railways, and other structures as shown on topographical maps

- areas committed to future development were considered to have a fairly low potential for rehabilitation, although there should be some limited opportunities

Figure A.5 shows the existing forest cover plus areas that may be suitable for naturalization. If one were actually doing a natural heritage system, the following additional steps would be completed:

- check areas proposed for rehabilitation in more detail by using 1:10,000 OBMs and/or recent aerial photography
- target additional areas that have high potential for sediment delivery to watercourses
- investigate existing land uses in more detail and possibly avoid large areas of high agricultural capability.

In the Upper Main, almost all of the streams have riparian habitat and sufficient buffers. It is therefore easy to target those that do not. In many areas, it may be possible to widen existing riparian corridors to strengthen linkages among major patches. When examining riparian areas for rehabilitation, focus first on publicly-owned lands and areas within regulated floodplains and fill lines. Also, look at the extent of coldwater streams to see if there are possibilities of improving habitat in a downstream direction. This might be accomplished through riparian plantings or removal or by-pass of ponds. Emphasis should also be placed on rehabilitating any headwater streams that are degraded.

A driving tour should also be taken of the subwatershed to look for opportunities and constraints that were not apparent from maps or photographs. This also allows identification of point sources such as livestock access sites, manure storage problems, milkhouse wastes and intermittent streams where grassed waterways would reduce sediment delivery.

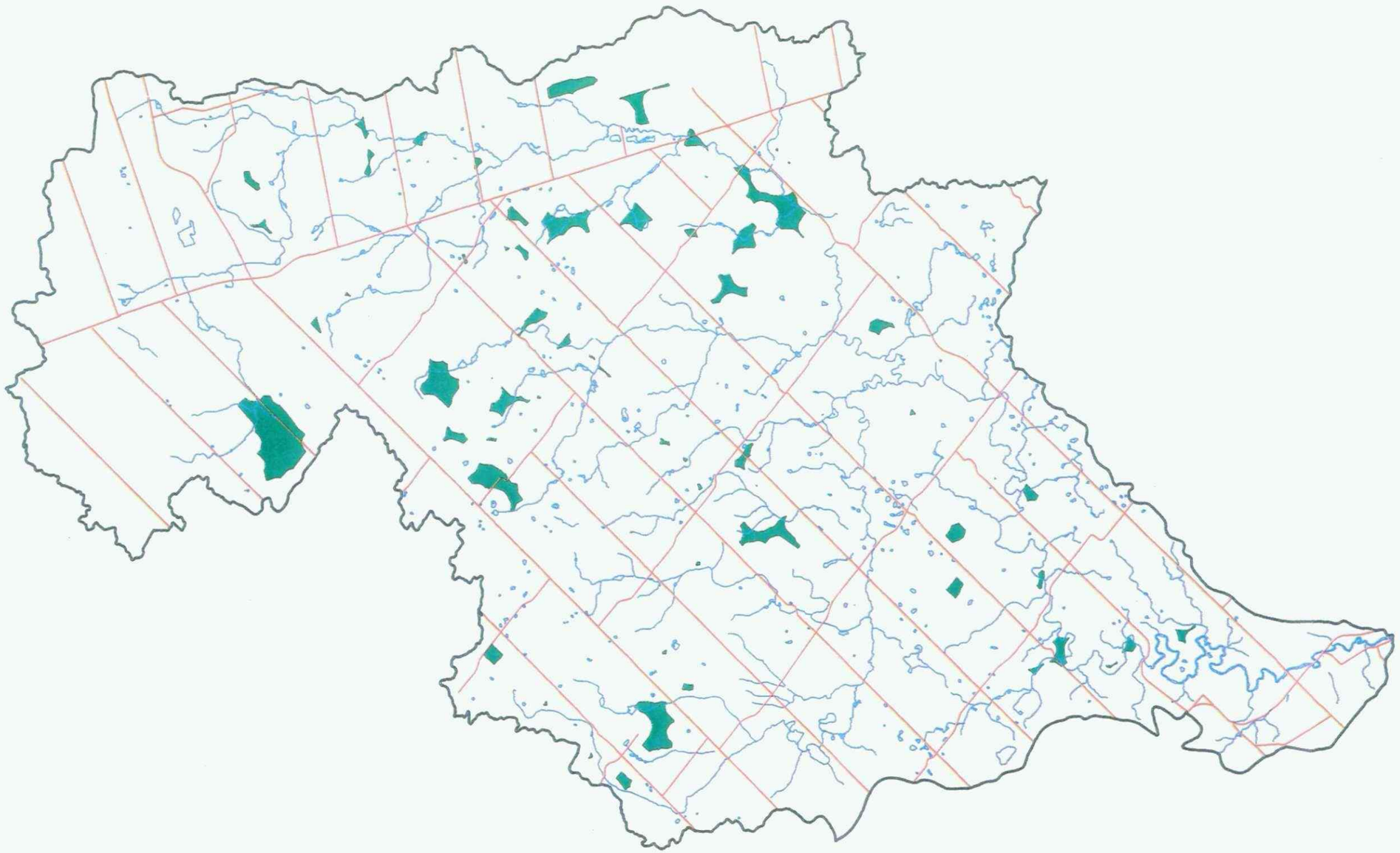
Table B.9 compares the natural heritage goals to existing and proposed conditions in the Upper Main. By increasing the amount of natural habitat by 5.3%, the percent forest cover 100 and 200 m from edge increased 9.1% and 7.2%, respectively (see Figures A.6 and A.7).

When planning an actual natural heritage strategy, habitats other than forest should be considered. Grasslands are valuable wildlife habitat and they are diminishing throughout the province. Restoration to prairie or even savannah habitat should be considered if historical vegetation information indicates that these communities were formerly present. In some instances, it may be possible to create marsh habitat.

The above natural heritage strategy for the Upper Main Humber subwatershed is totally conceptual. Implementing agencies need to take public opinion and existing and proposed land uses into account. Without this type of reality check, the strategy is unlikely to be acceptable to the public.

Step 4 - Implementation

Because the Upper Main subwatershed is distant from Lake Ontario, the Metro Toronto and Region Conservation Authority may be the most practical lead agency, with technical assistance from MNR. The MTRCA is already involved in the process through production of the Humber River Watershed



UPPER MAIN HUMBER
SUBWATERSHED

Existing 200 Metre Buffer
from Forest Edge

Woodlots

Roads

Drainage

1000 0 1000 2000
Meters

Scale 1:80,000

Project Name:
STRATEGY FOR RESTORING
FISH & WILDLIFE HABITAT
IN THE GREAT LAKES
AREAS OF CONCERN

Prepared For:
ENVIRONMENT CANADA
ENVIRONMENTAL CONSERVATION
BRANCH

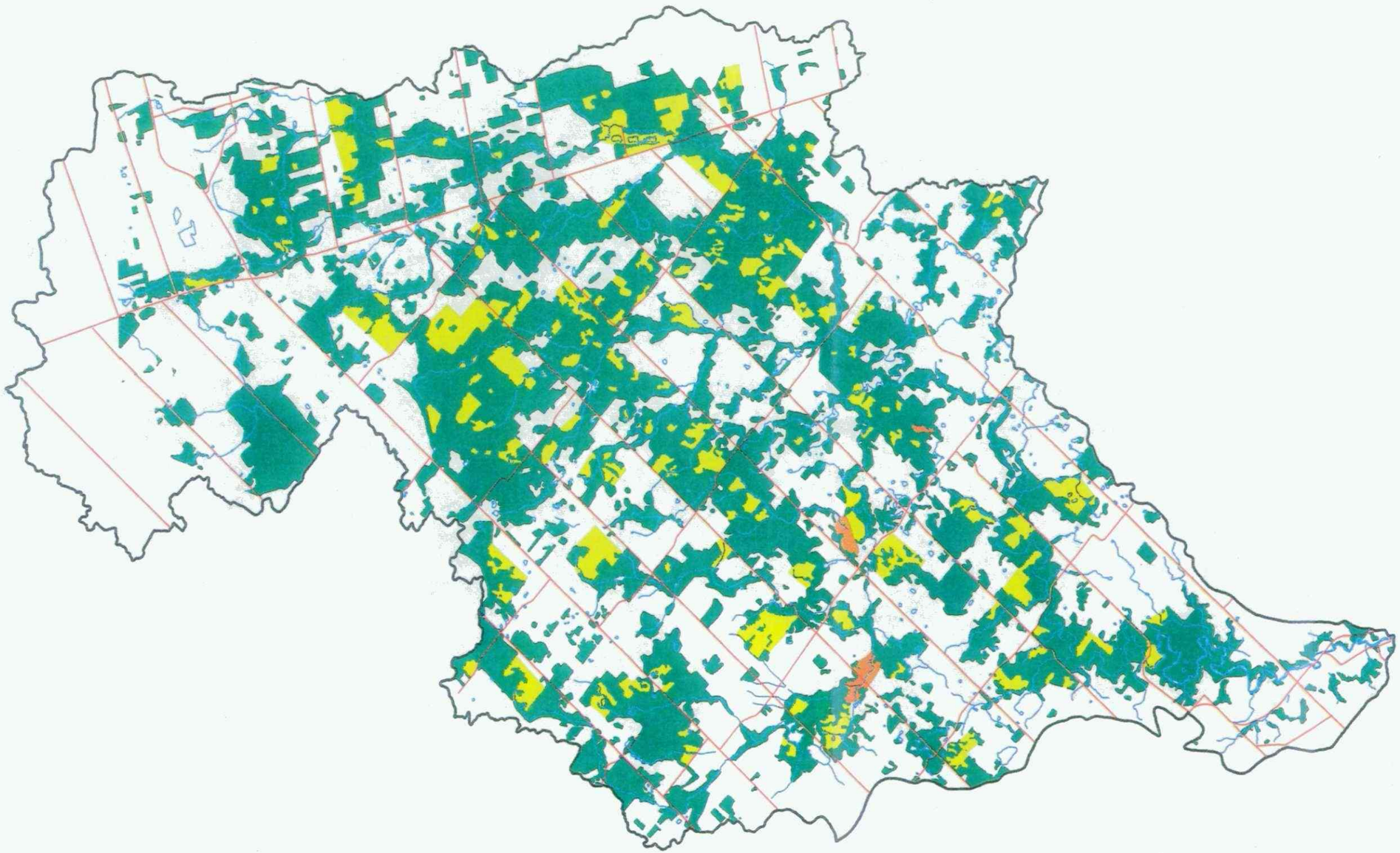
ECOLOGICAL SERVICES for PLANNING

Project: 95179

File Name: C4.map

Date: May 1995

Figure No.
A5



Conceptual Natural Heritage Strategy for the Upper Main Humber Subwatershed

- Areas Suggested for Naturalization
- Woodlots
- Wetlands
- Roads
- Drainage

1000 0 1000 2000
Meters

Scale 1:80,000

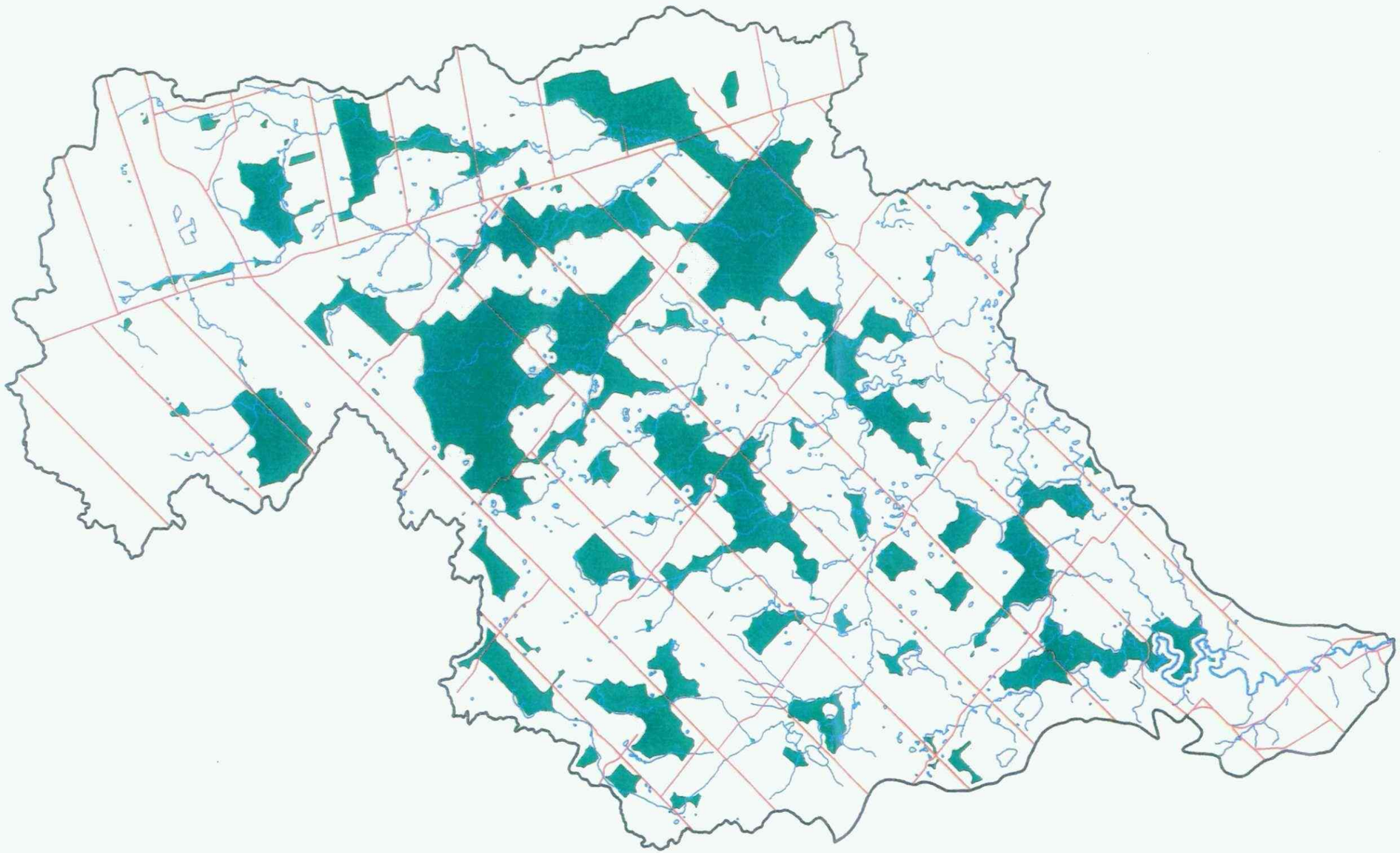
Project Name:
STRATEGY FOR RESTORING FISH & WILDLIFE HABITAT IN THE GREAT LAKES AREAS OF CONCERN

Prepared For:
ENVIRONMENT CANADA
ENVIRONMENTAL CONSERVATION BRANCH

ECOLOGICAL SERVICES for PLANNING

Project: 95179
File Name: C5.map
Date: May 1995

Figure No.
A6



N

UPPER MAIN HUMBER
SUBWATERSHED

Potential 100 Metre Buffer
from Forest Edge

Woodlots

Roads

Drainage

1000 0 1000 2000
Meters

Scale 1:80,000

Project Name:
STRATEGY FOR RESTORING
FISH & WILDLIFE HABITAT
IN THE GREAT LAKES
AREAS OF CONCERN

Prepared For:
ENVIRONMENT CANADA
ENVIRONMENTAL CONSERVATION
BRANCH

ECOLOGICAL SERVICES for PLANNING

Project:
95179

File Name:
C6.map

Date:
May 1995

Figure No.
A7

Atlas and the Natural Heritage System Subcommittee of the Humber River Task Force.

Once a draft strategy is formulated, it must be discussed with the public. Without public acceptance, it is highly unlikely that rehabilitation will occur. If public enthusiasm can be sparked, volunteers may take on small projects, and they may be eligible for Community Fisheries Involvement Program or Community Wildlife Involvement Program grants from MNR.

The Conservation Authority should also work with the Ontario Ministry of Agriculture, Food and Rural Affairs to deal with agricultural issues. Grants are available for many Best Management Practices that will improve fish and wildlife habitat. An education program may be necessary, as many farmers are unaware of all of the services that are available.

For areas where new tree cover is being recommended and for wildlife corridors, it is suggested that natural succession be allowed to take place instead of actively planting trees. The advantages of this are that the initial grasslands provide habitat to a different group of wildlife species, a better diversity and natural mix of plant species is obtained, and it is inexpensive. Where there is concern about the weedy look of earlier stages of succession, it may be necessary to plant native species.

For techniques on how to rehabilitate or create woodlands, meadows, wetlands, and other wildlife habitats, see McHattie *et al.* (1995) and HSWNDL and G&S (1995). These reports are available from the Canadian Wildlife Service and the Waterfront Regeneration Trust.

A natural heritage strategy is a long-term project. Results of reforestation will not be apparent for a minimum of 15 years and it could take considerably longer. The strategy should be included in Official Plans to ensure that land-use changes do not occur that are detrimental to the strategy.

Step 5 - Monitoring

Volunteer programs could be used to determine the effectiveness of the strategy in improving wildlife habitat. One bird species that is apparently absent in the subwatershed is the Red-shouldered Hawk. It is a forest-interior and area-sensitive species that should benefit from the proposed natural heritage strategy. The Long Point Bird Observatory coordinates a Red-shouldered Hawk survey that is undertaken by volunteers. By establishing a few survey routes in the subwatershed, it could easily and inexpensively be determined if Red-shouldered Hawks had become established.

The volunteer Forest Bird Monitoring Program (FBMP) could also be used as a monitoring tool. Sites where enhancement will be undertaken could be set up as FBMP plots to see if bird populations changed over time as a result of management. Woodlots of various size should be selected for monitoring including some that no management is proposed for as well as those whose shape and size will be improved. With appropriate design, the monitoring will measure the success of the wildlife enhancement program and indicate the time frame that is required before improvements are observed. Results should be applicable to a wide geographical area.

If one specific goal is to extend trout habitat farther downstream, this might be monitored simply by checking water temperatures. Casual observations could also be made for trout or spawning redds.

Monitoring may be required to ensure that strategies are actually implemented in the field. Landowners or landowners' practices may change. What was a grassed waterway one year may be a ploughed field the next, and new problem sites may occur. At least a windshield tour is required annually to check for new opportunities and constraints.

3. HABITAT REHABILITATION STRATEGY FOR THE WEST HUMBER SUBWATERSHED

Strategy Initiation
This step is identical to that for the Upper Main subwatershed.

Step 1 - Site Analysis
As shown on Figure A.8, the subwatershed is predominantly agricultural land. Only 6.7% of the subwatershed is forested. Only 0.3% of the subwatershed is forest cover 100 m or farther from edge (Figure A-9), and there is no forest 200 m from edge. The majority of the subwatershed is in the Great Lakes-St. Lawrence Forest Region, dominated by the same tree species that occur in the Upper Main Humber Subwatershed.

The extreme southern portion of the subwatershed and a small area in the southwest are situated in the Carolinian Forest Region. Within this region, typical tree species include black maple, shagbark hickory, sycamore, black walnut, blue beech, sweet chestnut, tulip tree, and red, white and bur oak. Almost all of the Carolinian forest has been cleared from the subwatershed. Only one tiny upland patch remains, but some tree cover persists in the stream valley.

The subwatershed does not contain many significant habitats. There are no provincially significant wetlands, although there are two wetlands which total 87 ha (0.4% of the subwatershed). Two small areas totalling 7 ha (0.03%) have been designated ESAs by MTRCA. No life sciences ANSIs occur in the subwatershed.

Tables B.1 through B.5 list the fish and wildlife species that may occur in the subwatershed, based on data provided by Steedman (1987) and the various atlases. Nineteen native fish species have been documented from the subwatershed. They include cool to coldwater species such as redside dace, rainbow darter and mottled sculpin, as well as species typical of larger, warmwater streams (carp, river chub, largemouth bass).

Only four common species of amphibians and two abundant reptile species have been reported in the subwatershed. Although the herpetofaunal diversity is low, some species have obviously been overlooked. The wood frog, which does appear to be present, requires fairly extensive forests with breeding pools. Based on the map of existing forest cover, it is probably restricted to larger woodlots in the northern part of the subwatershed and to forested riparian areas in the south.

Ninety-seven breeding birds were reported from the three OBBA squares that the subwatershed is in. This is 20 species fewer than reported from the Upper Main. Because some of the squares contain better habitat than exists in the subwatershed, it is probable that even fewer species are actually

Ontario

Ministry of Environment and Energy

Ministère de l'Environnement et de l'Énergie

135 St. Clair Avenue West
Suite 100
Toronto ON M4V 1P5

135, avenue St. Clair ouest
Bureau 100
Toronto ON M4V 1P5

Program Development Branch

(416) 314-7996
FAX 314-3924

February 12, 1996

MEMORANDUM

TO: Distribution list

FROM: Ian Smith
LaMP Coordinator
Industrial and Area Programs

RE: UPDATING PROGRESS UNDER COA - MARCH 1996

In light of the forthcoming disruptions, it seems prudent to temporarily "close the book and mark the page" on some items in which MOEE is a partner with others, who will also be affected by the pending staffing and other changes in MOEE. One book needing attention is the Canada-Ontario Agreement. I am aware of progress under many of the Stream 2 targets, and am requesting your assistance in documenting this progress as of March 31. Ron Shimizu has agreed that the federal leads on each target will have the responsibility for "reporting progress" through the use of the Great Lakes Information Tracking and Reporting (GLITR) system. We may not produce a "paper report" on Stream 2 in 1996, but will begin to utilize GLITR to periodically update progress nevertheless.

Staff at Environment Canada, together with Darryl Hogg, are updating GLITR so that it features several elements for tracking Stream 2 progress and it is becoming increasingly user friendly. I am requesting that you take half an hour (the length of one coffee break) and telephone your federal counterpart and ensure that they have sufficient information to update GLITR for your target on MOEE's behalf based upon the existing workplans. If you are computer literate, and are interested in how Environment Canada is attempting to track COA electronically, contact Darryl, Carol or myself for a demonstration - currently only 4 MOEE computers have access to GLITR, and given the impending financial changes, we do not anticipate increasing this level of accessability - rather we intend for the Federal staff member to take the responsibility for updating GLITR, but you may find it an interesting exercise to watch over their shoulder.

Ian Smith
cc: C. Sackville-Duyvelshoff
T. Tseng/D. Hogg
file: pdb\draftia6\6e020040.mem
attach: Distribution list

Distribution list:

Dolly Goyette	(2.1)
Nada Thornton	(2.2, 2.3)
Don Murray	(2.4)
Fred Granek/Pauline Desroches	(2.5, 2.10)
Neville Reid	(2.6)
Richard Aucoin	(2.7)
Ian Smith/Henri Selles	(2.9)
Steven Radcliffe	(2.11)
Gary Zikovitz	(2.12)
Peter Campbell	(2.13)
Walter Chan/Dan Orr	(2.14)

Carol Sackville-Duyvelshoff

Remedial Action Plan
Plan d'Assainissement

Steering Committee
February 1996

Re: Identifying Habitat Rehabilitation Targets and Priorities in Great Lakes Areas of Concern: Upland Systems released for comment

As part of Canada and Ontario's commitment to Remedial Action Plans (RAPs) and restoring beneficial uses across the basin, the RAP Steering Committee has embarked on several complementary initiatives concerning habitat rehabilitation.

This document, Identifying Habitat Rehabilitation Targets and Priorities in Great Lakes Areas of Concern: Upland Systems - An Interim Report (hereafter referred to as the Upland Systems document), provides a strategy for identifying upland habitat rehabilitation needs and priorities as compared to a set of targets using analysis techniques made available through geographic information sytem (G.I.S.) technologies. This document is currently being expanded to incorporate additional aquatic habitat targets. The final document is designed to provide RAP Coordinators, technical teams and Public Advisory Committees with an approach for more tangibly setting quantitative targets to guide habitat rehabilitation efforts towards the ultimate goal: restoring the loss of fish and wildlife beneficial use impairment (BUI).

In a related initiative, the RAP Steering Committee is examining how RAP priorities and recommendations can be integrated into municipal activities in conjunction with the new Planning Act, through municipal Official Plans (OP) and OP Amendments and municipal programs. Steering Committee is exploring how RAP objectives and activities can be better integrated with the legal municipal environmental assessment requirements and language included in municipal official plans..

Recently, two other complementary documents have been produced. To expand on the techniques available to RAPs for inventorying aquatic habitat, the Ontario Ministry of Natural Resources (OMNR) has recently released interim guidelines for aquatic habitat assessment. Environment Canada has produced a habitat rehabilitation techniques manual for shoreline, riparian zone and wetland habitat rehabilitation. These reports provide specific inventory and habitat rehabilitation techniques respectively.

Over the next six months, the Strategy will be tested in several AOC pilot sites: the Humber River watershed in Metro Toronto, the Niagara River, and the Spencer Creek watershed in Hamilton Harbour. RAP teams in these AOCs will be working with Conservation Authorities and municipalities to prepare maps of existing habitat in the watershed using geographic information system (G.I.S.) technologies and comparing existing conditions to the targets provided in the Upland Systems document. Following this analysis, these groups will identify rehabilitation project needs in the watershed that when implemented can move the RAP towards the targets, and therefore closer to restoring the habitat BUI. We anticipate that changes will be made to the Strategy as a result of these pilot tests.

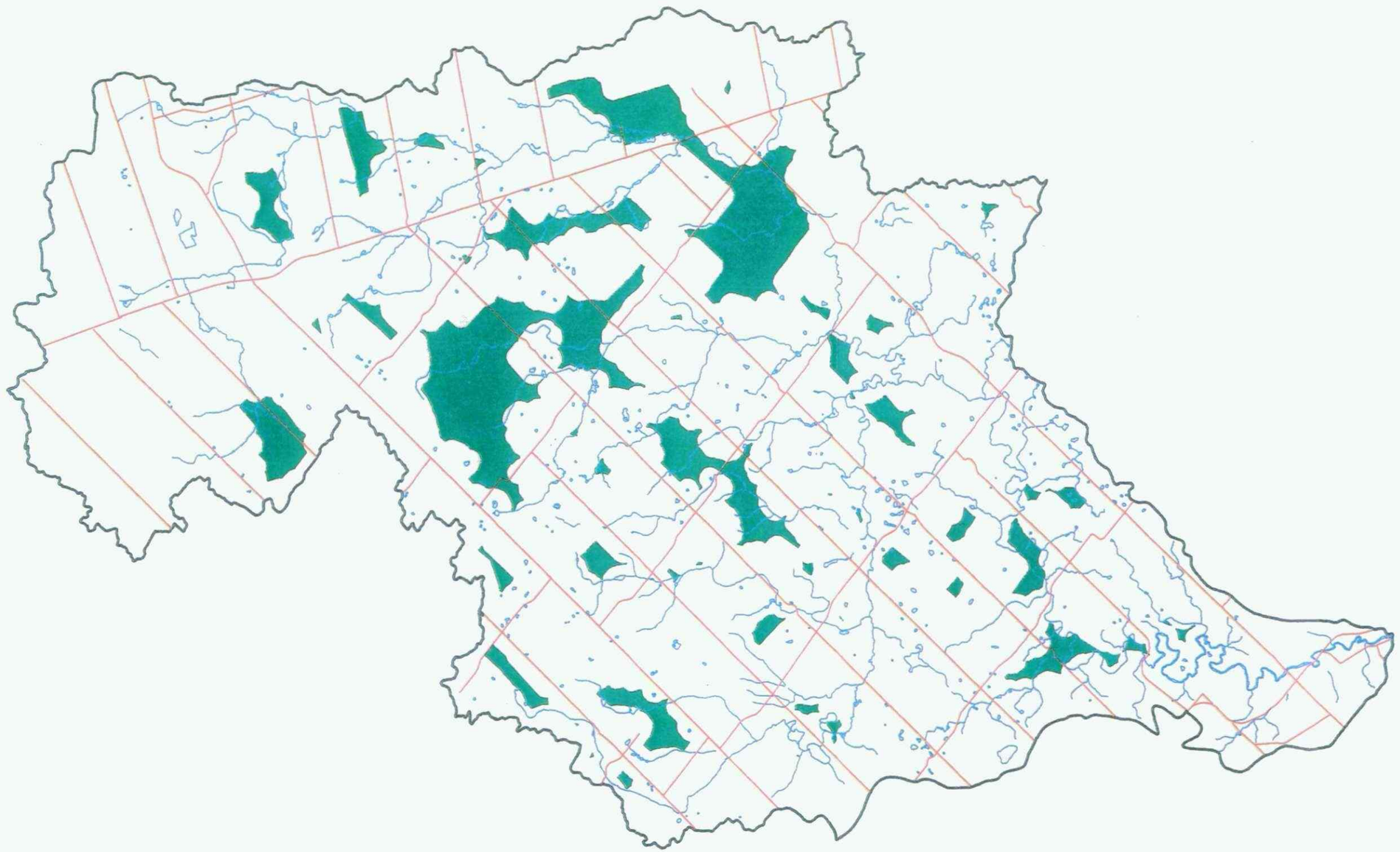
This interim strategy has been funded by Environment Canada's Great Lakes 2000 Cleanup Fund and the Ontario Ministry of Environment and Energy, with technical assistance from Environment Canada - Environmental Conservation Branch and the Ontario Ministry of Natural Resources.

We would like to encourage you to provide comments on the interim Upland Systems document by March 31, 1996 to Nancy Patterson, Environment Canada, Environmental Conservation Branch, 4905 Steeles Avenue, Downsview, Ontario M3H 5T4.

Yours truly,

Carole Sackville-Duyvelshoff
Ontario Ministry of Environment
and Energy

Danny Epstein
Environment Canada



UPPER MAIN HUMBER
SUBWATERSHED

Potential 200 Metre Buffer
from Forest Edge

Woodlots

Roads

Drainage

1000 0 1000 2000
Meters

Scale 1:80,000

Project Name:
STRATEGY FOR RESTORING
FISH & WILDLIFE HABITAT
IN THE GREAT LAKES
AREAS OF CONCERN

Prepared For:
ENVIRONMENT CANADA
ENVIRONMENTAL CONSERVATION
BRANCH

ECOLOGICAL SERVICES for PLANNING

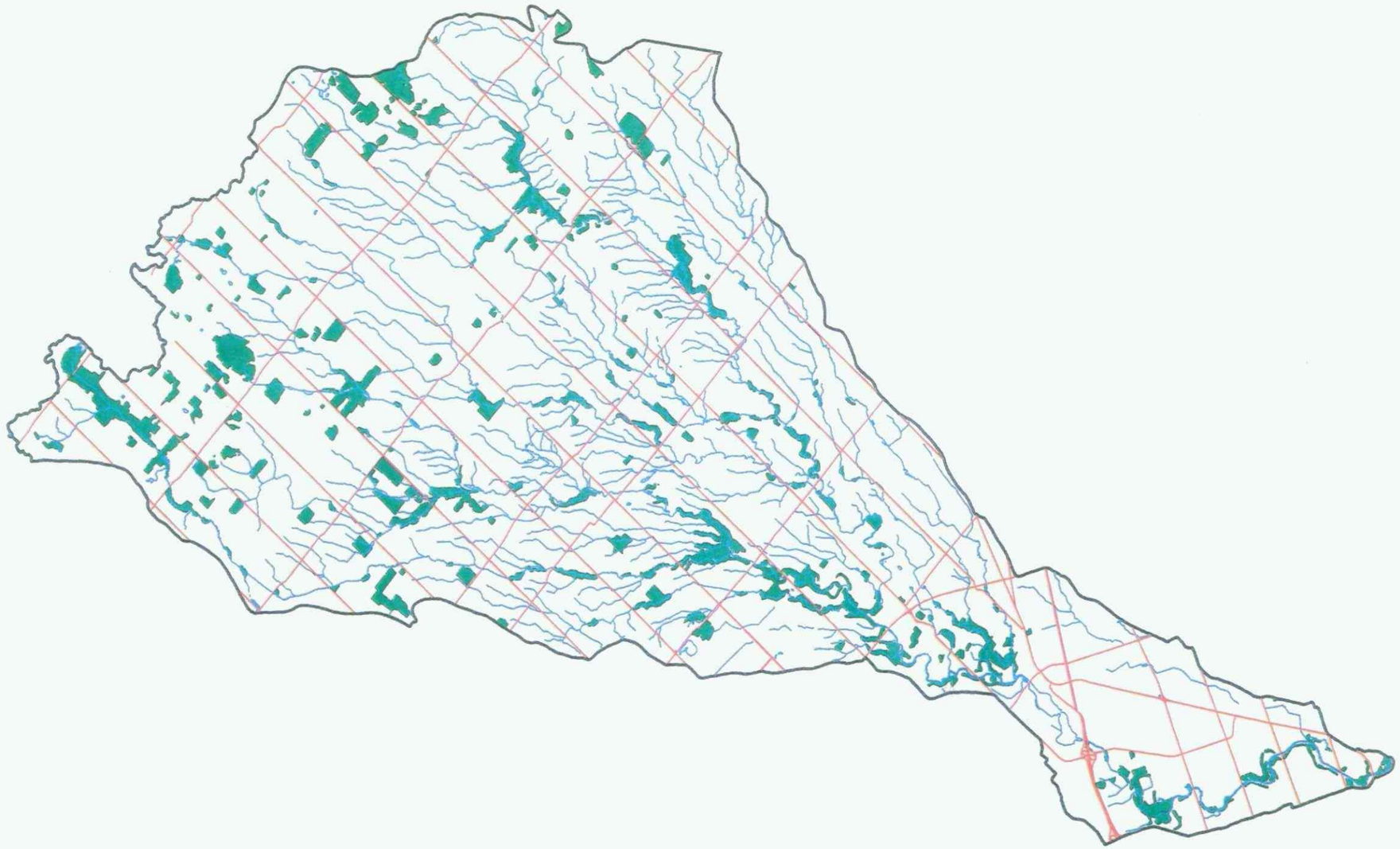
Project: 95179

File Name: C7.map

Date: May 1995

Figure No.

A8



WEST HUMBER SUBWATERSHED

Existing Forest Cover

Woodlots

Roads

Drainage

1000 0 1000 2000 3000

Meters

Scale 1:100,000

Project Name:

STRATEGY FOR RESTORING FISH & WILDLIFE HABITAT IN THE GREAT LAKES AREAS OF CONCERN

Prepared For:

ENVIRONMENT CANADA

ENVIRONMENTAL CONSERVATION BRANCH

ECOLOGICAL SERVICES for PLANNING

Project: 95179

File Name: Westhum.map

Date: May 1995

Figure No.

A9

present. Some species were reported that require extensive grasslands (Northern Harrier) or forest-interior habitat (Cooper's Hawk, Northern Goshawk, Winter Wren, Black-and-White Warbler, Ovenbird, Northern Waterthrush). This latter group of birds will be very scarce in the subwatershed and many may be absent.

Twenty-four mammal species have been reported from the subwatershed. These include the muskrat and mink, which are typically associated with marshes.

Step 2 - Historical Plant and Animal Analysis

Similar to the Upper Main, the West Humber Subwatershed was probably about 95% forested. It would have had the same tree composition as listed under the Upper Main, except for the area within the Carolinian Forest Region. Therefore, it probably originally supported a much higher diversity of plant and wildlife species than the Upper Main.

Table B.7 is a list of native fish and wildlife species that are apparently absent from the West Humber subwatershed. As was done in the other subwatershed, it was compiled by looking at the atlases for species that are present in the general geographic area, but absent in the squares in the subwatershed. Some of the species may actually be present but unreported because of difficulty finding or identifying them. As previously stated, some species apparently present may be absent as the atlas squares do not correspond well with the subwatershed boundary.

Fifty species are listed in Table B.7, and 42 of these appear to be absent. They include 3 fish, 4 amphibians, 2 reptiles, 29 birds and 4 mammals. Two of the missing fish (American brook lamprey, brook trout) require clear cold or cool streams. Of the missing amphibians, two are salamanders that require relatively large forests with woodland pools, and the pickerel frog is frequently associated with springs or cool waters. A high proportion of the missing bird species are forest-interior or area-sensitive species; several wetland bird species are also missing. The missing mammals include two (snowshoe hare, woodland jumping mouse) that require larger forests.

Step 3 - Habitat Rehabilitation Design

Table B.8 compares the features of the two example subwatersheds to the natural heritage goals. It is clear that the natural heritage attributes in the West Humber subwatershed are all well below the goals, except for the percentage of the subwatershed that is pervious. However, when committed development is taken into account, the percent perviousness drops by 7.0% to 86.4%, just above the goal.

Under normal circumstances, a high priority would be to restore native vegetation communities in the Carolinian Forest Region. The rationale for this is that this habitat is very limited in the study area (and Canada) and that it would greatly improve biodiversity. However, the Carolinian Forest Region within the subwatershed has either already been developed or committed to development.

Strategies for identifying areas with potential for naturalization were similar to those for the Upper Main. There were some differences:

- there is limited public land that provides good opportunities for rehabilitation; and
- due to the scarcity of forest cover, some new patches were proposed to lessen the degree of isolation.

A conceptual natural heritage strategy for the West Humber subwatershed is shown on Figure A.10. This strategy is considered very optimistic for the following reasons:

- some of the forest patches shown on the topographical map are orchards. During the screening processes of preparing an actual natural heritage system, these areas should not be depicted as forest;
- because of the high quality of the agricultural land, there would probably be higher than normal resistance to allowing areas to renaturalize; and
- the numerous existing buildings limit the areas that can be rehabilitated, and many of the areas shown on the conceptual plan probably involve multiple landowners.

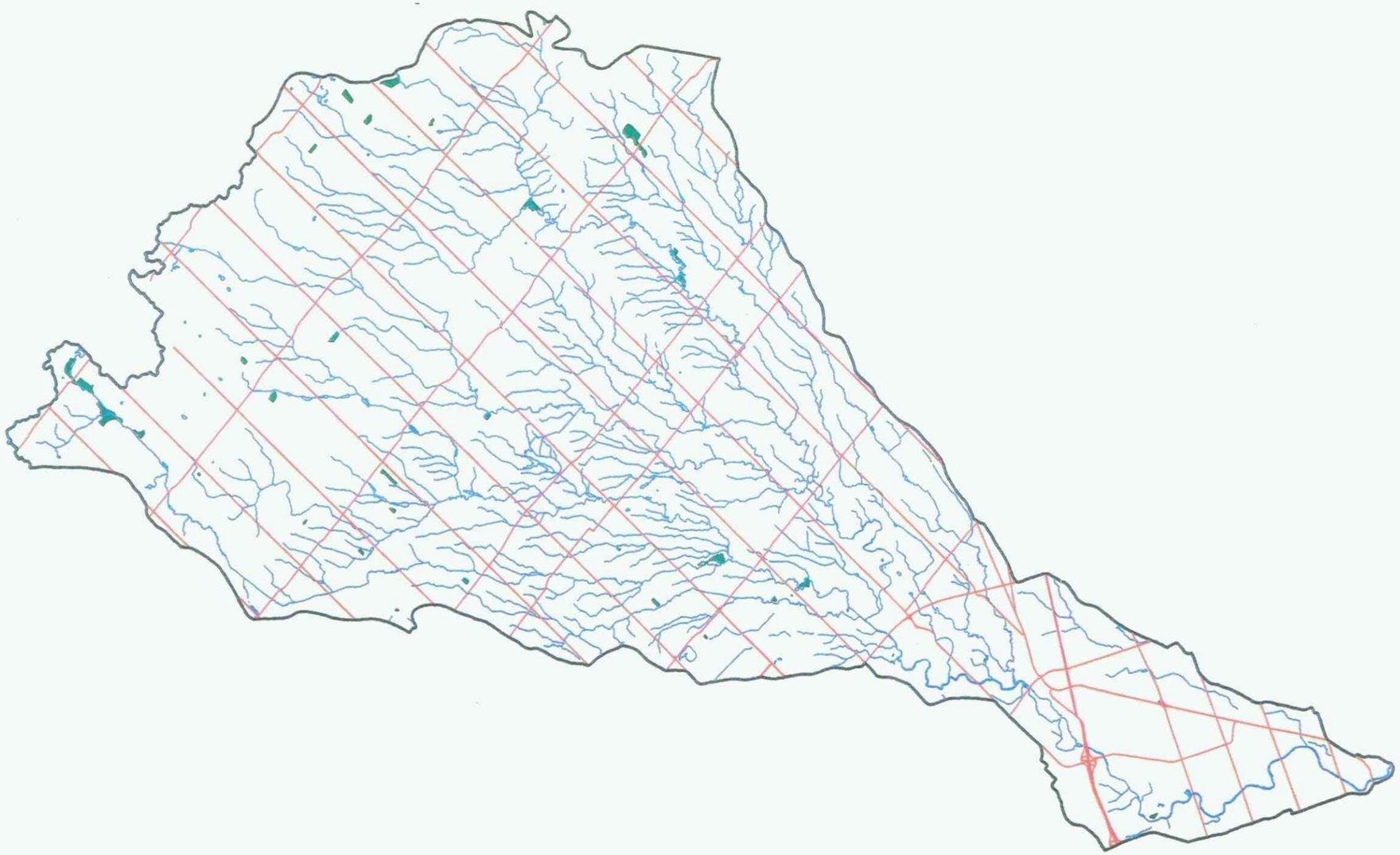
Table B.10 compares the natural heritage goals to existing and proposed conditions in the West Humber subwatershed. By increasing the amount of natural habitat by 8.7%, the percent forest cover 100 and 200 m from edge increased 6.5% and 3.1%, respectively (see Figures A.11 and A.12).

All of the goals listed in Table B.10 have been achieved except for the percentage of forest cover and interior forest habitat. Currently over 30% of the bird species that should occur in the West Humber subwatershed are apparently absent. Depending on the type of forest cover provided, 17 to 20 of the 29 bird species that are apparently missing could recolonize the subwatershed. Some of the species that require extensive forest cover, such as Red-shouldered Hawk and Barred Owl, will probably continue to be absent. In addition, marsh-dependent species that are absent will require development of extensive marshlands if they are to re-occur in the area. Given the existing conditions, there are limited opportunities for this.

Re-establishing riparian habitats in this subwatershed is a challenge because of the numerous first and second order streams in high quality agricultural land. Thirty metre buffers along every stream would remove significant areas of land from production. Nonetheless, this subwatershed is probably responsible for a high percentage of the total suspended solids and total phosphorus delivered to Lake Ontario from the entire Humber River Watershed. Remediation in this subwatershed could help achieve overall water quality objectives for the AOC.

An actual strategy for improving riparian habitat in the West Humber subwatershed needs to be done on a site-specific basis and is beyond the scope of this exercise. The following are some suggestions, some of which have probably already been implemented:

- protect all areas that have been identified as supporting redside dace or rainbow darters;
- if possible, improve these areas and extend habitat downstream;
- identify areas of high potential sediment delivery using the Universal Soil Loss Equation or other accepted models. Target these areas for conservation tillage or naturalization and actively promote this with landowners;



WEST HUMBER SUBWATERSHED

Existing 100 Metre Buffer from Forest Edge

Woodlots

Roads

Drainage

1000 0 1000 2000 3000

Meters

Scale 1:100,000

Project Name:

STRATEGY FOR RESTORING FISH & WILDLIFE HABITAT IN THE GREAT LAKES AREAS OF CONCERN

Prepared For:

ENVIRONMENT CANADA

ENVIRONMENTAL CONSERVATION BRANCH

ECOLOGICAL SERVICES for PLANNING

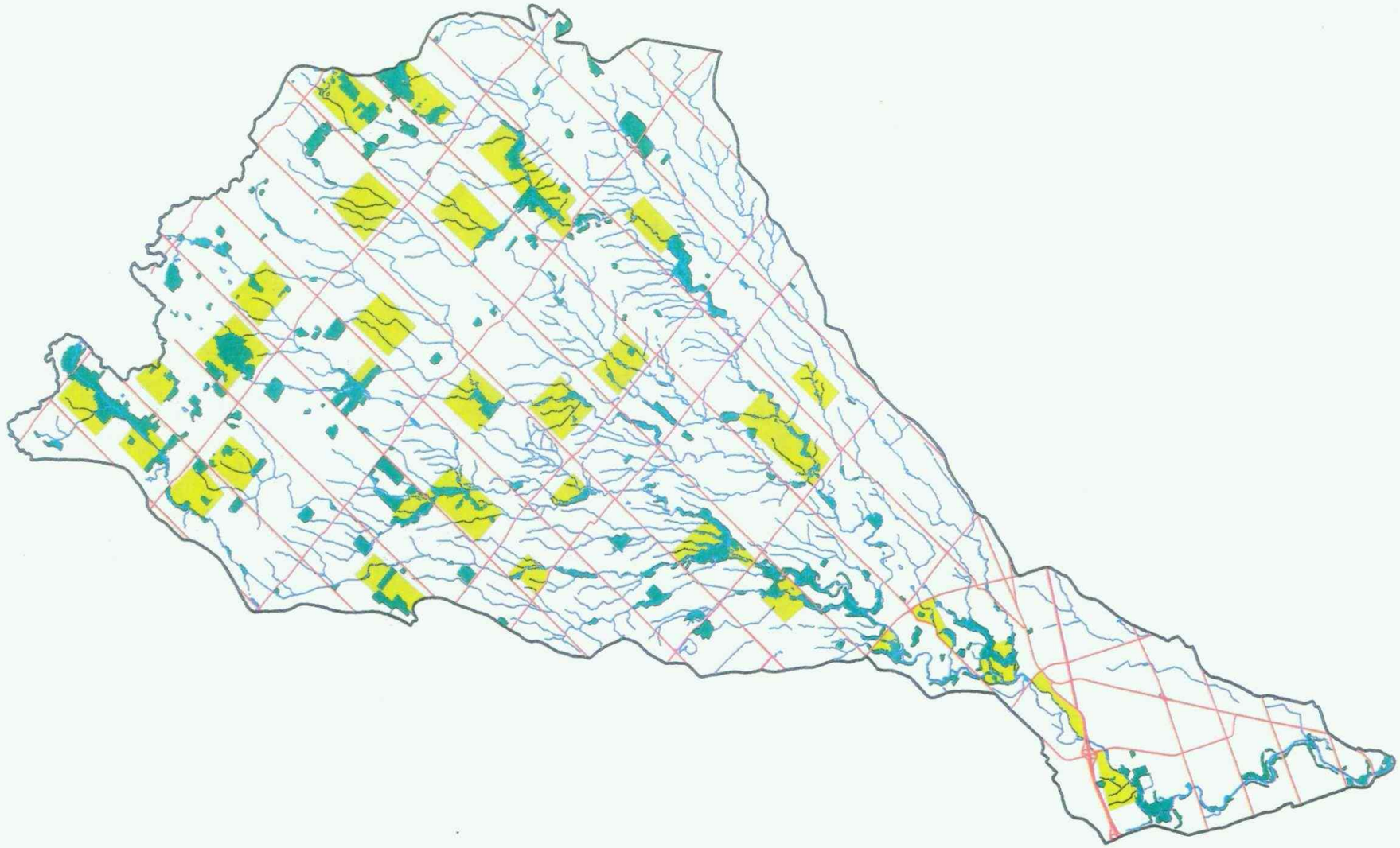
Project: 95179

File Name: Hum100.map

Date: May 1995

Figure No.

A10



Conceptual Natural Heritage Strategy for the West Humber Subwatershed

- Areas Suggested for Naturalization
- Woodlots
- Roads
- Drainage

1000 0 1000 2000 3000
Meters

Scale 1:100,000

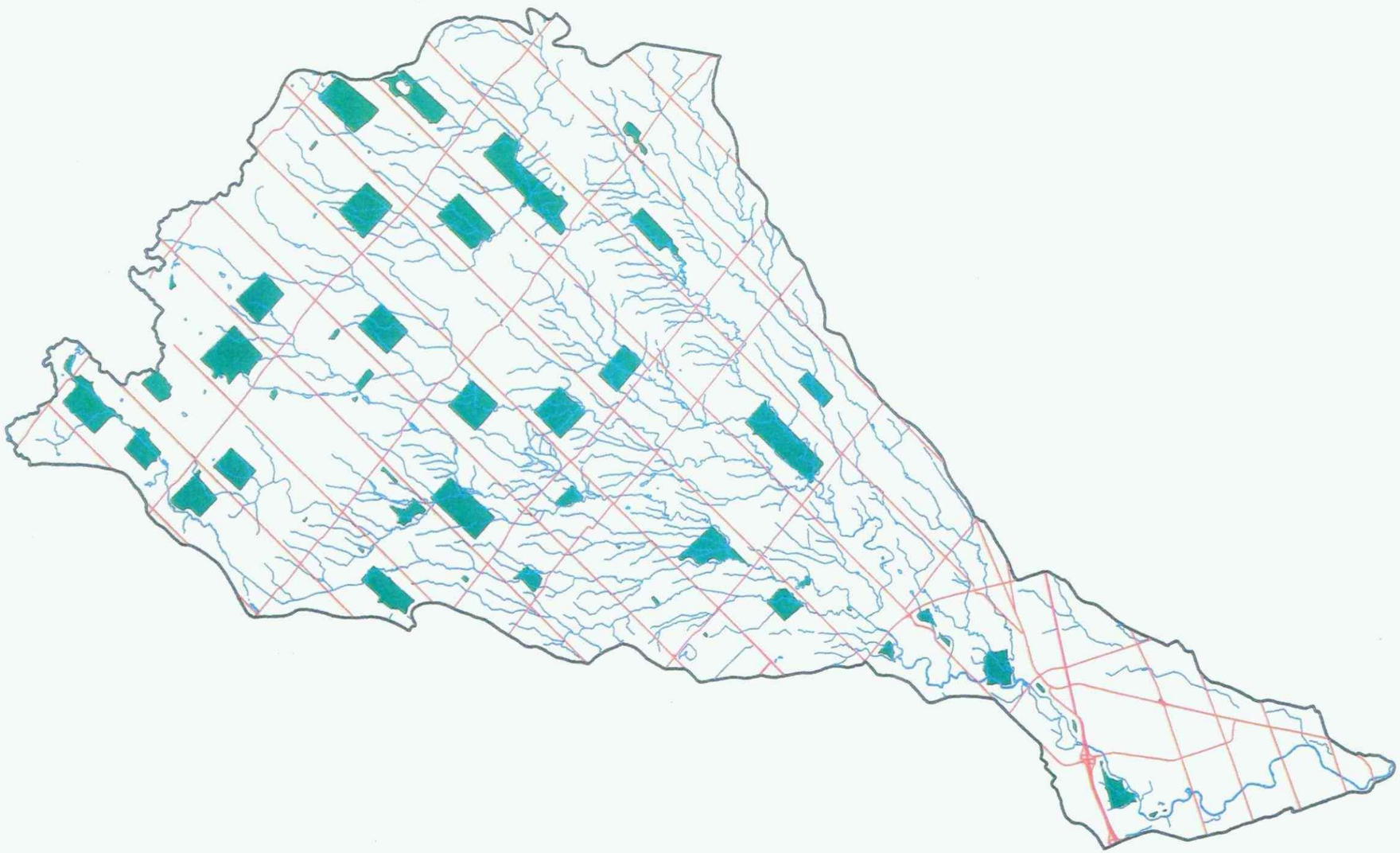
Project Name:
STRATEGY FOR RESTORING FISH & WILDLIFE HABITAT IN THE GREAT LAKES AREAS OF CONCERN

Prepared For:
ENVIRONMENT CANADA
ENVIRONMENTAL CONSERVATION BRANCH

ECOLOGICAL SERVICES for PLANNING

Project: 95179
File Name: C10.map
Date: May 1995

Figure No.
A11



N

WEST HUMBER SUBWATERSHED

Potential 100 Metre Buffer from Forest Edge

Woodlots

Roads

Drainage

1000 0 1000 2000 3000

Meters

Scale 1:100,000

Project Name:

STRATEGY FOR RESTORING FISH & WILDLIFE HABITAT IN THE GREAT LAKES AREAS OF CONCERN

Prepared For:

ENVIRONMENT CANADA

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ECOLOGICAL SERVICES for PLANNING

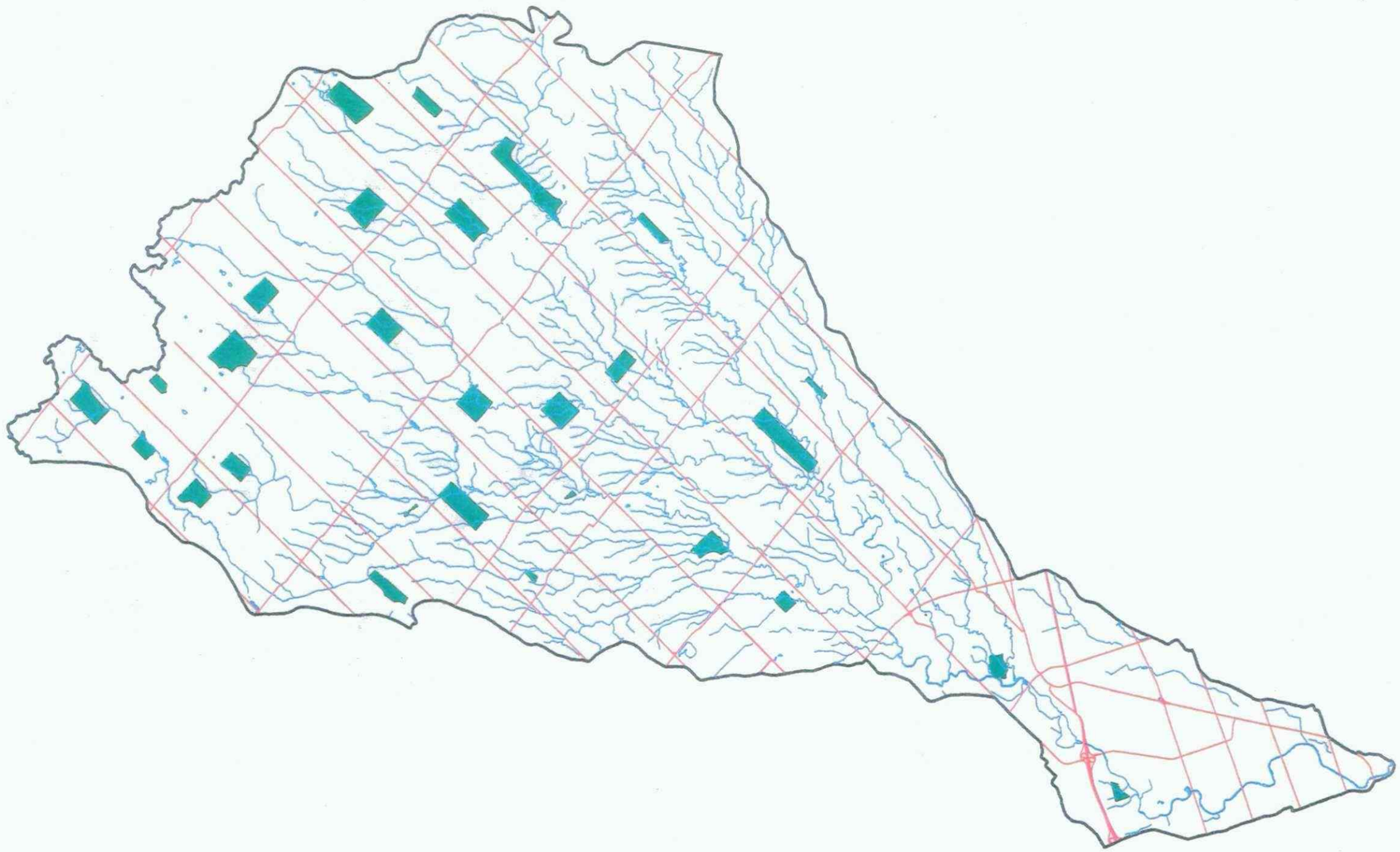
Project: 95179

File Name: C11.map

Date: May 1995

Figure No.

A12



WEST HUMBER SUBWATERSHED

Potential 200 Metre Buffer from Forest Edge

Woodlots

Roads

Drainage

1000 0 1000 2000 3000

Meters

Scale 1:100,000

Project Name:

STRATEGY FOR RESTORING FISH & WILDLIFE HABITAT IN THE GREAT LAKES AREAS OF CONCERN

Prepared For:

ENVIRONMENT CANADA

ENVIRONMENTAL CONSERVATION BRANCH

ECOLOGICAL SERVICES for PLANNING

Project: 95179

File Name: C12.map

Date: May 1995

Figure No.

A13

APPENDIX B - LIST OF SPECIES IN MAIN AND WEST HUMBER EXAMPLE WATERSHEDS INCLUDING IDENTFICATION OF EXPECTED SPECIES MISSING

Table B.1. Fish Species Documented in the Example Subwatersheds (Steedman, 1987)

Species	Upper Main	West
Brown Bullhead		x
Brook Stickleback	x	
Rock Bass	x	x
Pumpkinseed	x	x
Largemouth Bass		x
Yellow Perch		x
+ Rainbow Darter		x
Iowa Darter	x	
Fantail Darter	x	x
Johnny Darter	x	x
+ Mottled Sculpin	x	x
Number of Species	**19**	**20**
Number of Native Species	**18**	**19**

* Introduced Species
\+ Species with Specialized Habitat Requirements

Table B.2. Amphibian Species in the Example Subwatersheds (Weller and Oldham, 1988)

Species	Upper Main	West
American Toad	x	x
Spring Peeper	x	x
Gray Treefrog	x	
Striped Chorus Frog	x	
+ Wood Frog	x	x
Northern Leopard Frog	x	
+ Pickerel Frog	x	
Green Frog	x	x
Number of Species	**8**	**4**

\+ Species with Specialized Habitat Requirements

Table B.3. Reptile Species in the Example Subwatersheds (Weller and Oldham, 1988)

Species	Upper Main	West
Common Snapping Turtle	x	
Midland Painted Turtle	x	x
Eastern Garter Snake	x	x
Northern Redbelly Snake	x	
Brown Snake	x	
Number of Species	**5**	**2**

Table B.4. Breeding Bird Species in the Example Subwatersheds (Cadman *et al.*, 1987)

Species	Upper Main	West
+ American Bittern	x	
Great Blue Heron	x	x
Green Heron	x	x
Canada Goose	x	x
Wood Duck	x	x
American Black Duck	x	
Mallard	x	x
Blue-winged Teal	x	x
Turkey Vulture	x	
+ Northern Harrier	x	x
+ Sharp-shinned Hawk	x	
+ Cooper's Hawk	x	x
+ Northern Goshawk		x
+ Broad-winged Hawk	x	
Red-tailed Hawk	x	x
American Kestrel	x	x
Ring-necked Pheasant	x	x
Ruffed Grouse	x	x
+ Wild Turkey	x	
Virginia Rail	x	
Sora	x	x

Table B.4. Breeding Bird Species in the Example Subwatersheds (Cadman *et al.*, 1987)

Species	Upper Main	West
+ American Coot	x	
Killdeer	x	x
Spotted Sandpiper	x	x
+ Upland Sandpiper	x	x
+ Common Snipe	x	x
+ American Woodcock	x	x
Herring Gull	x	
Rock Dove	x	x
Mourning Dove	x	x
Black-billed Cuckoo	x	x
Yellow-billed Cuckoo	x	
Eastern Screech-Owl	x	
Great Horned Owl	x	x
+ Long-eared Owl	x	
Common Nighthawk	x	x
+ Whip-poor-will	x	
Chimney Swift	x	x
Ruby-throated Hummingbird	x	x
Belted Kingfisher	x	x
Red-headed Woodpecker	x	x
+ Yellow-bellied Sapsucker	x	x

Table B.4. Breeding Bird Species in the Example Subwatersheds (Cadman *et al.*, 1987)

Species	Upper Main	West
Downy Woodpecker	x	x
Hairy Woodpecker	x	x
Northern Flicker	x	x
+ Pileated Woodpecker	x	
Eastern Wood-Pewee	x	x
Alder Flycatcher	x	x
Willow Flycatcher	x	x
Least Flycatcher	x	x
Eastern Phoebe	x	x
Great Crested Flycatcher	x	x
Eastern Kingbird	x	x
Horned Lark	x	x
Purple Martin	x	
Tree Swallow	x	x
Northern Rough-winged Swallow	x	x
Bank Swallow	x	x
Cliff Swallow	x	x
Barn Swallow	x	x
Blue Jay	x	x
American Crow	x	x
Black-capped Chickadee	x	x

Table B.4. Breeding Bird Species in the Example Subwatersheds (Cadman *et al.*, 1987)

Species	Upper Main	West
+ Red-breasted Nuthatch	x	x
White-breasted Nuthatch	x	x
+ Brown Creeper	x	
House Wren	x	x
+ Winter Wren	x	x
+ Marsh Wren		x
+ Golden-crowned Kinglet	x	
+ Blue-gray Gnatcatcher	x	x
Eastern Bluebird	x	
+ Veery	x	x
+ Wood Thrush	x	x
American Robin	x	x
Gray Catbird	x	x
Northern Mockingbird	x	
Brown Thrasher	x	x
Cedar Waxwing	x	x
European Starling	x	x
Warbling Vireo	x	x
Red-eyed Vireo	x	x
Nashville Warbler	x	x
Yellow Warbler	x	x

Table B.4. Breeding Bird Species in the Example Subwatersheds (Cadman *et al.*, 1987)

Species	Upper Main	West
Chestnut-sided Warbler	x	x
+ Magnolia Warbler	x	
Yellow-rumped Warbler	x	
+ Black-throated Green Warbler	x	
+ Pine Warbler	x	x
+ Black-and-white Warbler	x	x
American Redstart	x	x
+ Ovenbird	x	x
+ Northern Waterthrush	x	x
Mourning Warbler	x	x
Common Yellowthroat	x	x
Canada Warbler	x	
+ Scarlet Tanager	x	x
Northern Cardinal	x	x
Rose-breasted Grosbeak	x	x
Indigo Bunting	x	x
Rufous-sided Towhee	x	x
Chipping Sparrow	x	x
Field Sparrow	x	x
Vesper Sparrow	x	x
Savannah Sparrow	x	x

Table B.4. Breeding Bird Species in the Example Subwatersheds (Cadman *et al.*, 1987)

Species	Upper Main	West
Grasshopper Sparrow	x	x
Song Sparrow	x	x
Swamp Sparrow	x	x
White-throated Sparrow	x	x
+ Bobolink	x	x
Red-winged Blackbird	x	x
Eastern Meadowlark	x	x
Common Grackle	x	x
Brown-headed Cowbird	x	x
Orchard Oriole		x
Northern Oriole	x	x
+ Purple Finch	x	
House Finch	x	x
Pine Siskin		x
American Goldfinch	x	x
House Sparrow	x	x
Number of Species	**117**	**97**

\+ Species with Specialized Habitat Requirements

Table B.5. Mammal Species in the Example Subwatersheds (Dobbyn, 1994)

Species	Upper Main	West
Common Shrew	x	
Smoky Shrew	x	
Northern Short-tailed Shrew	x	x
Star-nosed Mole	x	
Little Brown Bat		x
Big Brown Bat		x
Eastern Cottontail	x	x
+ Snowshoe Hare	x	
European Hare	x	x
Eastern Chipmunk	x	x
Woodchuck	x	x
Gray Squirrel	x	x
Red Squirrel	x	x
Northern Flying Squirrel	x	
Beaver	x	x
White-footed Mouse	x	x
Deer Mouse		x
Meadow Vole		x
+ Muskrat	x	x
Norway Rat		x
Meadow Jumping Mouse	x	x

Table B.5. Mammal Species in the Example Subwatersheds (Dobbyn, 1994)

Species	Upper Main	West
Porcupine	x	x
Coyote	x	x
Red Fox	x	x
Raccoon	x	x
Ermine		x
+ Mink	x	x
Striped Skunk	x	x
White-tailed Deer	x	x
Number of Species	**23**	**24**

\+ Species with Specialized Habitat Requirements

Table B.6. Species Apparently Absent from the Upper Main Humber Subwatershed

A. Fish
+ Redside Dace
Longnose Dace
+ Rainbow Darter

B. Amphibians
+ * Jefferson Salamander complex
+ * Yellow-spotted Salamander
* Eastern Redback Salamander

C. Reptiles
* Eastern Smooth Green Snake
* Eastern Milk Snake

Table B.6. Species Apparently Absent from the Upper Main Humber Subwatershed

D. Birds

+ Pied-billed Grebe
Hooded Merganser
+ Northern Goshawk
+ Red-shouldered Hawk
+ Common Moorhen
+ Barred Owl
+ Marsh Wren
Yellow-throated Vireo
+ Blackburnian Warbler
+ Cerulean Warbler
Pine Siskin

E. Mammals

* Little Brown Bat
* Big Brown Bat
* Deer Mouse
* Meadow Vole
+ Woodland Jumping Mouse
Ermine

* Probably overlooked
\+ Species with Specialized Habitat Requirements

Number of Species: 25

Number (excluding overlooked species): 16

Table B.7. Species Apparently Absent from the West Humber Subwatershed

A. Fish

+ American Brook Lamprey
+ Brook Trout
+ Iowa Darter

Table B.7. Species Apparently Absent from the West Humber Subwatershed

B. Amphibians

+ Jefferson Salamander complex
+ Yellow-spotted Salamander
* Eastern Redback Salamander
Gray Treefrog
* Striped Chorus Frog
* Northern Leopard Frog
+ Pickerel Frog

C. Reptiles

* Common Snapping Turtle
Northern Redbelly Snake
* Brown Snake
Eastern Smooth Green Snake
* Eastern Milk Snake

D. Birds

+ Pied-billed Grebe
+ American Bittern
American Black Duck
Hooded Merganser
Turkey Vulture
+ Sharp-shinned Hawk
+ Red-shouldered Hawk
+ Broad-winged Hawk
+ Wild Turkey
Virginia Rail
+ Common Moorhen
+ American Coot

Table B.7. Species Apparently Absent from the West Humber Subwatershed

Yellow-billed Cuckoo
Eastern Screech-Owl
+ Barred Owl
+ Long-eared Owl
+ Whip-poor-will
+ Pileated Woodpecker
+ Brown Creeper
+ Golden-crowned Kinglet
Eastern Bluebird
Yellow-throated Vireo
+ Magnolia Warbler
Yellow-rumped Warbler
+ Black-throated Green Warbler
+ Blackburnian Warbler
+ Cerulean Warbler
Canada Warbler
+ Purple Finch

E. Mammals
* Common Shrew
* Smoky Shrew
Star-nosed Mole
+ Snowshoe Hare
Northern Flying Squirrel
+ Woodland Jumping Mouse

* Probably overlooked
\+ Species with Specialized Habitat Requirements

Number of Species: 50
Number (excluding overlooked species): 42

Table B.8. Comparison of the Subwatersheds to the Natural Heritage Goals

Parameter	Goal	Upper Main	West
Percent Natural Area	> 30	34.9	6.7
Largest Natural Habitat Patch	100 ha	400 ha	52 ha
Percent Forest Cover 100 m from Edge	> 10	9.4	0.3
Percent Forest Cover 200 m from Edge	> 5	2.2	0.0
Percent of Streams with Riparian Habitat	> 75	93.3	8.7
Percent of Streams with 30 m Buffers	> 75	92.7	7.9
Percent of Watershed that is Pervious	> 85	93.8	93.4

Table B.9. Upper Main Humber Subwatershed - Existing and Proposed Conditions

Parameter	Goal	Existing	Proposed
Percent Natural Area	> 30	34.6	39.9
Largest Natural Habitat Patch	100 ha	400 ha	950 ha
Percent Forest Cover 100 m from Edge	> 10	9.4	18.5
Percent Forest Cover 200 m from Edge	> 5	2.2	9.4
Percent of Watershed that is Pervious	> 85	93.8	89.1

Table B.10. West Humber Subwatershed - Existing and Proposed Conditions

Parameter	Goal	Existing	Proposed
Percent Natural Area	> 30	6.7	15.4
Largest Natural Habitat Patch	100 ha	52 ha	160 ha
Percent Forest Cover 100 m from Edge	> 10	0.3	6.8
Percent Forest Cover 200 m from Edge	> 5	0.0	3.1
Percent of Watershed that is Pervious	> 85	93.4	86.4

Appendix C. List and summary of existing databases, videos, maps, atlases, legislation and guidelines and general references relevant to aquatic habitat inventory on the Great Lakes Areas of Concern (From Ball, 1995)

AERIAL PHOTOGRAPHS

1. Historical Airphotos of Ontario available through Natural Resources Information Centre-Toronto Room M1-73 Macdonald Block, 900 Bay Street Toronto, Ontario M7A 2C1 (416) 314-2000.

2. Colour infrared photography of all of Ontario at a variety of scales began in 1994 by the OMNR Remote Sensing Office, ICI House, 1st Floor, 90 Sheppard Avenue East, North York, Ontario M2N 3A1 (416) 314-8482.

3. Black and white aerial photographs 1:8000 and 1:2000 of all southern Great Lakes flown in 1988/1989. Environment Canada retained half of the photos (OMNR has the other half). A quite extensive series of photos exists for Lakes Erie, Ontario, Huron and Superior taken in 1985 and 1986. Other assorted photographs of various scales and locations taken in the 1950's, 1960s, 1970's and 1980's. Available through Mr. Ralph Moulton, Environment Canada, Great Lakes Water Level Communications, P.O. Box 5050, 867 Lakeshore Rd. E., Burlington, Ontario L7R 4A6 (905) 336-4580.

4. National Historical Airphotos of Canada from 1920's to present located in the National Air Photo Library, Ottawa. Phone (613) 995-4560.

5. Ducks Unlimited have a series of aerial photographs on Great Lakes wetlands from early 1970's to present. Available through Mr. Ron Maher, Ducks Unlimited Canada, 566 Welham Road, Barrie Ontario L4M 6E7. (705) 721-4444.

6. Ontario Hydro has recent and historical aerial photos of rivers and streams in Ontario, and are available through Jeff Forsythe, Transmission Projects, Ontario Hydro 700 University Avenue, Toronto, Ontario (416) 506-5096 or (416) 592-5111. They will perform a search to see what aerial photos are available (historic and recent) for the rivers and streams you are interested in. The name of the river or stream, and towns/cities in the area of interest need to be provided.

   Ontario Hydro also has an archive of historical photographs. Historical aerial photos of rivers and streams in Ontario, and are available through the Archives of Ontario Hydro, 800 Kipling Avenue, Toronto, Ontario (416) 207 6729. Aerial photos may be obtained by visiting the centre, where you must perform your own search.

VIDEOS

1. **Environment Canada**, Environmental Protection Branch Colour Video tapes: Video tapes of the entire Great Lakes Shoreline were taken in 1991 and 1992. These were all shot from a helicopter flying at an altitude of approximately 50-100 m and a distance of several hundred metres offshore. The survey was conducted to create an atlas for mitigation of damage caused by potential oil spills. The narrative focused primarily on the nature of the beach/water interface. In general the tapes are of excellent quality, and the shoreline description may be interpreted both from the video tape and from the accompanying commentary. Contact: Philip Baker, Protection and Prevention Branch, Environment Canada 25 St. Clair Avenue East, 7th Floor, Toronto, Ontario M4T 1M2 (416) 973 5854

2. **Ontario Ministry of Natural Resources**, District Offices: For example: Sault Ste. Marie District and Thunder Bay District Offices have recent videos of the shoreline of the St. Mary's River and Lake Superior, respectively.

MAPS/ACCOMPANYING REPORTS

1. National Topographic Map Series (NTS) at a scale of 1:25000, 1:50000, 1:250000 are available in hard copy and in digital format from the Canada Map Office, Department of Energy, Mines and Resources, Ottawa, K1A 0E9 (613) 952-7000.

2. Ontario Base Maps 1:10000 for Southern Ontario, 1:20000 for Northern Ontario are available from the Natural Resource Information Centre, Rm M173, MacDonald Block, 900 Bay St., Toronto, Ontario M7A 2C1 (416) 314-2000.

3. Canadian Hydrographic Maps - General and Offshore Charts, Coastal and Approach Charts, Harbour Charts, Small Craft Charts Available from Dept. of Fisheries and Oceans, Ottawa (613) 998-4931 or through a local dealer.

4. Canada-Ontario Flood Damage Reduction Program Maps illustrating topographic features including contours, wooded areas, buildings, roads, usual water extent of rivers, regulatory flood line, pint elevations, geo-references. Available from Conservation Authorities and OMNR District Offices.

5. Shoreline Inventory Maps 1:15840 describes subaqueous slope to 5 foot contour, substrate (silt, sand, gravel, boulder etc.), backshore slope. Contact: Tracey Ellis Remote Sensing Branch, OMNR, 90 Sheppard Avenue East, North York, Ontario, M2N 3A1 (416) 313 1319.

6. Shoreline Erosion Monitoring Maps available from Conservation Authorities.

7. Forest Resource Inventory (FRI) maps 1:15840 available from Natural Resource Information Centre, Rm M1-73 Macdonald Block, 900 Bay St. Toronto, Ontario, M7A 2C1 (416) 314 2000

8. Wetland Mapping Series, 3rd Approximation. Lands Directorate, Environment Canada (Ontario Region), 1983. 128 maps. Available from Federation of Ontario Naturalists, 355 Lesmill Rd Don Mills M3B 2W8 (416) 444-8419

9. Wetland Evaluation Maps available from OMNR District Offices.

10. County Soils Maps 1:25000 and Soil Reports available from the Consumer Information Centre, Ontario Ministry of Agriculture and Food, 801 Bay Street, Toronto, Ontario M7A 2B2 (416) 326-3400.

11. Canada Land Inventory Maps (CLI) entitled "Soil Capability for Agriculture" at a scale of 1:50000 are available from the Canada Map Office, Department of Energy, Mines and Resources, Ottawa, Canada K1A 0E9 (613) 952-7000.

12 Geology Maps, Ministry of Northern Development and Mines (MNDM) including Surficial Geology Maps 1:50000; Quaternary Geology Maps 1:50000 -1:1000000; Ontario Geological Survey Reports; Peat and Peatland Resource Reports. Available from Publications Department, MNDM, Sudbury (705) 670-5691

13. MOEE, Water Resource Report Series. Available through the Program Development Technical Resource Centre, OMOEE, 14th Floor, 40 St Clair Ave W. Toronto, Ontario M4V 1P5 (416) 314-7959.

14. Groundwater and Surface Water Quality Reports. Available through the Public Information Centre, OMOEE, 1st Floor, 135 St. Clair Ave. W., Toronto, Ontario M4V 1P5 (416) 323-4321.

15. Watershed Maps available through local Conservation Authorities

DATABASES/ATLASES

1. **Ontario Digital Topographic Database (ODTDB)**: Hardcopies and digitized Ontario Base Maps at a scale of 1:10000 for southern Ontario and 1:20000 for northern Ontario. Digitizing of southern Ontario Base Maps is nearly complete. Contact: Tom Malone, Land and Resource Information Branch, Provincial Mapping and Data Base, OMNR, 90 Sheppard Avenue East, 4th Floor, North York, Ontario M2N 3A1 (416) 314-1215.

2. **National Topographic System of Canada:** Hardcopies and digitized topographic maps of Canada. Hardcopy maps at a scale of 1:50000; 1:250000; 1:1000000; and discontinued scales 1:25 000 and 1:500 000. Hardcopy maps are available through Canada Map Company, 211 Yonge Street, Toronto, Ontario M5B 1M4 or Canada Map Office, Natural Resources Canada, 615 Booth Street, Ottawa, Ontario K1A 0E9 (613) 995-2123. Out of print maps 1:25 000 and 1:500 000 may be available for use at some libraries. Digital topographic data at a scale of 1:50000 (incomplete) and 1:250000 are available from Digital Distribution Services, Products and Services Division, 615 Booth Street, Room 400, Ottawa, Ontario K1A 0E9 (613) 995-0314.

3. **Ontario Watersheds Database**: database containing information on discharge and water levels for Ontario watersheds extending back to the 1900's and updated continually as data become available. Information is derived from a variety of sources of information including Surface Water Data Ontario Historical Streamflow Summary, Historical Water Levels Summary, Sediment Data for Canadian Rivers and Historical Sediment Data Summary published by Water Survey of Canada, Environment Canada. Contact: Herman Goertz, Monitoring and Systems Branch, Environment Canada, 75 Farquhar Street, Guelph, Ontario N1H 3N4 (519) 823-4200.

4. **Coastal Zone Database**, Environment Canada: database was established as part of the 1986 International Joint Commission Levels Reference Study. Digitizing of shoreline reaches, land use, flood and erosion lines, bathometry (2m and 5m), and buildings were completed for all of Lakes Erie, Ontario, and St. Clair, the St Clair and Detroit Rivers, and southern Lake Huron to just north of Sauble Beach on a NTS map sheet basis. Some land use and building coverage were digitized for approximately half of the NTS sheets which cover the shoreline of Lake Superior, but no reach or bathymetry data was included. No land use or other information was digitized for the remainder of Lake Huron or any of the St. Lawrence River (more data available but not digitized). The landuse information is summarized in a report and maps (Triton Engineering and Ecologistics Ltd. 1992). All wetlands digitized (from wetland mapping series) for Lake Erie Basin. Niagara River is mapped - all point loadings, wetlands, fish habitat, shoreline reaches, bathymetry and buildings. Contact: Wendy Leger, Environmental Services Branch Environment Canada, Canada Centre for Inland Waters, P.O. Box 5050, 867 Lakeshore Road, Burlington, Ontario L7R 4A6 (905) 336-4630.

5. **Shoreline Atlas and Database for Spills**, Environment Canada includes shoreline habitat description, biological resources, human-use resources, physical overview at 1:50000. Available from Environment Canada, Environmental Protection Branch - Ontario Region, 25 St. Clair Avenue E., Toronto, Ontario, M4T 1M2 (416) 973-5854.

6. **Great Lakes Water Quality Database**: database providing information on water and sediment quality in the Great Lakes. For data requests call or send a letter to Doug Kennedy, Environmental Information and Systems Section, OMOEE, 12th Floor, 40 St. Clair Ave. W., Toronto, Ontario M4V 1M2 (416) 784-7864.

7. **Storage and Retrieval Database (STAR) and Envirodat Database**: database providing historical and recent information on water quality in the Great Lakes. For data requests, call Frances Philbert, Ecosystem Health Division, Environment Canada, Canada Centre for Inland Waters, P.O. Box 5050, 867 Lakeshore Rd., Burlington, Ontario L7R 4A6 (905) 336-4663.

8. **Provincial Water Quality Monitoring Network**: database providing information on water quality in inland streams, rivers and lakes. For data requests, call Brian Whitehead, Surface Water, OMOEE, West Wing 125 Resources Road, Etobicoke, Ontario M9P 3V6.

9. **Great Lakes Sediment Database**: database providing information on near shore substrate at survey points one kilometer apart. Contact: Norm Rukavina, Dept. Fisheries and Oceans, Canada Centre for Inland Waters, 867 Lakeshore Road, Burlington, Ont. L7R 4A6 (905) 336-4999.

10. **Database of Morphological Characteristics of Watercourses in Southwestern Ontario**: database providing information on tributaries in southwestern Ontario. Contact: Jack Imhoff, Research, Science and Technology Branch, Aquatic Research Section, OMNR, P.O. Box 5000, Maple, Ontario L6A 1S9 (905) 832-7173.

    Database of Morphological Characteristics of Urban Watercourses in Southwestern Ontario: database providing information on tributaries in urban areas of southwestern Ontario. Contact: Jack Imhoff, Research, Science and Technology Branch, Aquatic Research Section, OMNR, P.O. Box 5000, Maple, Ontario L6A 1S9 (905) 832-7173.

11. **Canada Great Lakes Basin Intake and Outfall Atlas**, Volumes 1-8, Ontario Ministry of the Environment. Available on loan through Program Development Technical Resource Centre, OMOEE (416) 314-7959.

12. **Natural Heritage Information System (NHIS)**: database providing information on location and site of protected areas (parks, Areas of Natural and Scientific Interest (ANSI), International Biological Program Sites, Environmentally Sensitive Areas, land protected by non-governmental organizations and Conservation Authorities, rare species and their habitats and species at risk. It include species identified and rankings of protection from the Natural Heritage Information Centre, Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and the Ontario Endangered Species Act. It should be available through OMNR District Offices. Contact: George Van Drunen or Susan Raichyk Systems Development Branch, Integrated Natural Resources Information Systems Section, OMNR, P.O. Box 7000, Peterborough, Ontario (705) 740-1492.

13. **National Conservation Areas Database**: Areas protected by federal and provincial governments, Conservation Authorities, and many NGOs, including Ontario Heritage League, Nature Conservancy of Canada, Federation of Ontario Naturalists, Niagara Escarpment Commission, Royal Ontario Museum, Queen's University, and Ducks Unlimited. Contact: Tony Turner, Environmental Reporting, Environment Canada, 9th Floor, Place Vincent Massey, 351 St-Joseph Blvd., Ottawa, Ontario K1A OH3 (819) 994-6029.

14. **Protected Areas and Areas of Natural and Scientific Interest Databases**: series of databases including Ontario Provincial Parks database, Conservation Areas Guide, Parks and Other Provincially owned Protected Natural Areas Database and ANSI Database. Contact: Tom Beechy, Provincial Parks and Natural Heritage Policy Branch, OMNR, 90 Sheppard Avenue East, 6th Floor, North York, Ontario M2N 3A1 (416) 314-1101 or George Cordiner, Provincial Parks and Natural Heritage Policy Branch, OMNR, P.O. Box 7000, Peterborough, Ontario K9J 8M5.

15. **Wetland Evaluation Information Management System (WEIMS)**, OMNR: digital database containing wetland name, UTM coordinates, class, size and number, percentage area of bog, fen,

swamp and marsh, site type, ownership and catchment. Contact: Kevin Ferth, Brockville Area Office, P.O. Box 605 Oxford Avenue, Brockville, Ontario K6V 5Y8 (613) 342 8524

16 **Ontario Fisheries Information System**, OMNR: The FISHLIB (Fisheries Information Library) database contains summaries of information collected and processed using FISHNET or CREESYS field software. Information in FISHLIB is obtained from aquatic habitat inventory surveys, commercial harvest reporting, commercial deck and port sampling, creel surveys, sport fishing diaries, sport fish sampling index fishing surveys, fish stocking, observations of significant events, observations of critical habitats, habitat rehabilitation, harvest controls, and waterbody synopses. FISHLIB is updated annually with datasets that are received by the OFIS Unit. FISHARC provides a storage location for raw data from fisheries surveys datasets. In the fall of 1994 the Ontario Fish Distribution Database (OFDD) which contains fish collection records from lake surveys, stream surveys, Royal Ontario Museum and the Canadian Museum of Nature should also be included as part of OFIS. Contact: Fergus McNeil OFIS, OMNR, 10401 Dufferin Street P.O. Box 5000, Maple, Ontario L6A 1S9 (905) 832-7292.

17. Goodyear, C.D., T.A. Edsall, D.M.O. Dempsey, G.D. Moss, and P.E. Polanski. 1982. **Atlas of the Spawning and Nursery Areas of the Great Lakes Fishes.** Office of Biological Services. US Fish and Wildlife Service. Washington, D.C.

18. **Contaminants in Fish**: database containing information on contaminants in commercial fish for export. Contact: Marilyn Hendzel, Inspection Services Branch, Dept. of Fisheries and Oceans, Freshwater Institute 501 University Crescent, Winnipeg, Manitoba R3T 2N6 (204) 983-5067.

19. **OMOEE Contaminants Database**: database for the Guide to Eating Sportfish in Ontario. Provides information on contaminant levels in sportfish. Contact: Andre Vaillancourt, Biomonitoring, OMOEE 12th Floor 40 St Clair Avenue West, Toronto, Ontario M4V 1M2. (416) 314-7902.

20. **Juvenile Fish Biomonitoring Program Database and reports**: database containing information on contaminants in shiners for the purpose of identifying areas of concern in nearshore waters of the Great Lakes. Shiners have been collected and tested from more than 150 sites on the Great Lakes and Connecting Channels between 1975-present. Contact: G. Hitchin, Environmental Monitoring and Reporting Branch, Biomonitoring, OMOEE, 125 Resources Road, Etobicoke, Ontario M9P 3V6 (416) 235 5802.

21. **Great Lakes Contaminants Surveillance Program**: database containing information on contaminants in Great Lakes Sport Fish. Contact: Mike Whittle, Bayfield Institute, Great Lakes Laboratory for Fisheries and Aquatic Sciences, Department of Fisheries and Oceans, P.O. Box 5050, 867 Lakeshore Road, Burlington, Ontario L7R 4A6 (905) 336-4565.

22. **Wildlife Contaminants Database**: database containing information on contaminant levels in wildlife. Canadian Wildlife Service, Environment Canada, Canada Centre for Inland Waters, P.O. Box 5050, 867 Lakeshore Rd, Burlington, Ontario L7R 4A6 (905) 336-4968.

23. **Ontario Mammal Atlas and Database**: database containing information on mammal distribution and range from the Atlas of the mammals of Ontario. Contact: Annette Page, Federation of Ontario Naturalists, 355 Lesmill Rd., Don Mills, Ontario M3B 2W8. (416) 444-8419. Note: Now available from NHIC database.

24. **Ontario Breeding Bird Atlas and Database**: database containing information from the Atlas of the breeding birds of Ontario. Contact: Annette Page, Federation of Ontario Naturalists, 355 Lesmill Rd., Don Mills, Ontario M3B 2W8. (416) 444-8419. Note: now available from NHIC database.

25. **Ontario Rare Breeding Bird Program Atlas and Database**: database containing information on rare breeding birds in Ontario. For reasons of site confidentiality, each request is reviewed on an individual bases, and information is only provided on a "need to know" basis. Contact: Annette Page, Federation of Ontario Naturalists, 355 Lesmill Rd., Don Mills, Ontario M3B 2W8. (416) 444-8419.

26. Peck, G.R. and R.D. James. 1983. **Breeding Birds of Ontario: Nidiology and Distribution**, Vols. 1 and 2, Life Sci. Misc. Publ., Royal Ontario Museum., Toronto, Ontario; Ontario Nest Record Scheme Annual Reports.

27. **Atlas of Colonial Waterbirds Nesting on the Canadian Great Lakes** (5 parts)
Hans Blokpoel and Gaston Tessier, Canadian Wildlife Service. For information contact H. Blokpoel, Canadian Wildlife Service, Ontario Region, 49 Camelot Drive, Nepean, Ontario K1A OH3 (613) 952-2410.
Part 1 Cormorants, Gulls and Island-Nesting Terns on Lake Superior in 1989 (Technical Report # 181)
Part 2 Cormorants, Gulls and Island-Nesting Terns on Lake Huron in 1989. (in preparation)
Part 3. Cormorants, Gulls and Island-Nesting Terns on the Lower Great Lakes system in 1990 (in preparation)
Part 4. Marsh Nesting Terns on Lake Huron and the Lower Great Lakes system in 1991 (in preparation).
Part 5. Herons and Egrets in the Great Lakes System During 1989-1991 (in preparation)

    Blokpoel H. and G. Tessier. 1991. Distribution and Abundance of Colonial Waterbirds nesting in the Canadian portions of the Lower Great Lakes System in 1990. Technical Report Series No. 117. Canadian Wildlife Service.

28. **Great Lakes Waterfowl Staging Survey in Great Lakes Areas of Concern:** project (in preparation) to identify location and numbers of staging waterfowl along the shorelines of the Great Lakes Areas of Concern. Proposed output is a series of maps showing location, numbers and species in a GIS format. Contact: Ken Ross, Canadian Wildlife Service, 49 Camelot Drive, Nepean, Ontario K1A 0H3 (613) 952-2415.

29. **Amphibian and Marsh Birds Monitroing Program in Great Lakes Areas of Concern:** project initiated in 1995 to monitor amphibians and marsh birds in Areas of Concern. Contact: Mike Cadman, Canadian Wildlife Service, 75 Farquhar Street, Guelph, Ontario N1H 3N4 (519) 766-1594.

30. **Ontario Herpetofaunal Summary Database**: database on amphibian distribution developed by the Ontario Field Herpetologists. Contact: Mike Oldham, Natural Heritage Information Centre, OMNR, P.O. Box 7000, Peterborough, Ontario K9J 8M5. (705) 745-5575.

31. Weller, W.F. and M.J. Oldham, eds., 1988. **Ontario herpetofaunal summary, 1986.** Ontario Herpetologists, Cambridge. 221 p.

- actively promote stream buffers to landowners. In most cases, 30 m buffers will be impractical and unacceptable to landowners. Consider as alternative guidelines a buffer width of six times full channel width or the distance that is required for the adjacent vegetation to prevent sediments from reaching the stream;
- identify and remediate point sources such as livestock access areas, manure storage problems and discharges of milkhouse wastes; and
- identify septic systems close to watercourses and implement an inspection program.

Step 4 - Implementation
This is identical to what is required for the Upper Main Humber subwatershed.

Step 5 - Monitoring
Monitoring is also similar to that suggested for the Upper Main. Monitoring for Red-shouldered Hawks is not a high priority, as the landscape is still only about 15% forested.

APPENDIX B - LIST OF SPECIES IN MAIN AND WEST HUMBER EXAMPLE WATERSHEDS INCLUDING IDENTFICATION OF EXPECTED SPECIES MISSING

Table B.1. Fish Species Documented in the Example Subwatersheds (Steedman, 1987)

Species	Upper Main	West
+ American Brook Lamprey	x	
* Brown Trout	x	
+ Brook Trout	x	
Central Mudminnow	x	
White Sucker	x	x
Northern Hog Sucker		x
Northern Redbelly Dace	x	
+ Redside Dace		x
* Carp		x
Brassy Minnow	x	
River Chub		x
Common Shiner	x	x
Bluntnose Minnow	x	x
Fathead Minnow	x	x
Blacknose Dace	x	x
Longnose Dace		x
Creek Chub	x	x